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ORIGINAL ARTICLES.

I.—The Antarctic Ice-cap.

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In a recent number of the Geological Magazine, Dec. V, Vol. III, March, 1906, p. 120, there is an article by Prof. E. H. L. Schwarz which deals with the thickness of ice-caps during the various Glacial periods. At the outset Professor Schwarz takes the data furnished by Captain Scott's narrative of the voyage of the "Discovery" as the main support of the physicists' contention that an ice-sheet cannot exceed 1,600 feet in thickness.

It is true that at the present day no ice more than 1,600 feet has been recorded. Dr. Nansen estimates the thickness of the Greenland ice-sheet to be nearly four times that amount, and, judging by the size of the icebergs said[1] to have been met with in the Southern seas, maintains[2] that the Antarctic Ice-cap must attain a very great thickness. These estimates, however, may be neglected, as the recent expeditions seem to show that the size of icebergs recorded in the Antarctic seas has been exaggerated. Both Von Drygalski[3] and Captain Scott[4] show that in times past the ice-caps of Greenland and South Victoria Land respectively attained a much greater thickness than they do now, and if we wish to prove that ice-sheets ever exceeded the 1,600 feet limit we have only the traces left by previous Glacial periods to fall back upon.

The thickness of an ice-sheet or iceberg, estimated by means of the unsubmerged height, is only very approximate. Von Drygalski gives 300 feet as the maximum height above water, and maintains that any iceberg which is higher than 300 feet must have turned over. In high latitudes the air is commonly misty, though in certain

[1] H. C. Russell: Journal of the Royal Society of New South Wales, vol. xxxi (1897), p. 241, reference number 172.
[2] Nansen: *Nature*, vol. lvii (1898), p. 424.
[3] Drygalski: Greenland Expedition, p. 33.
[4] Scott: Geog. Journ., April, 1905, p. 360.

localities clear bright days predominate: under these conditions, when no shadows are produced, it is exceedingly difficult to be certain which was originally the upper surface of a disintegrated iceberg. The accompanying illustration shows an iceberg estimated to be 200 feet high which still has a portion of its original upper surface intact. If this portion were removed it would be extremely difficult to make sure whether the berg had turned over or not. To argue that such icebergs as those figured in a great number of publications have all turned over, is hardly safe, especially as bodies with diameters of unequal length appear, in the majority of cases, to float with the longer diameter horizontal. It therefore seems highly improbable that a berg would increase its height by turning over.

A berg, however, may increase its height, and probably often does so, in the following way. A newly calved iceberg usually has vertical sides; the waves beat against these and, undermining them,

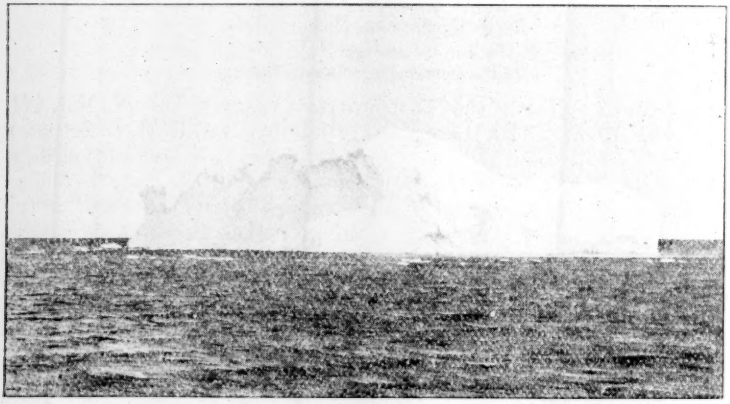


Fig. 1.—An iceberg which has turned through nearly 90°.

cause pieces to split off. This splitting will probably take place along vertical planes, parallel to inherent planes of weakness, and this undermining is accelerated by the temperature of the water at the surface being raised by radiant heat from the sun. The visible part of the berg will thus be reduced in mass, and consequently the berg will rise. That this is a common occurrence may be seen in almost any of the narratives of polar voyages, where one constantly finds references to the toe of an iceberg.

For icebergs floating freely in the sea, Von Drygalski gives the proportion of normal glacier ice above water to ice below water as 1 is to 4. Rink[1] makes the proportion as 1 is to 6; Steenstrup as 1 is to 7; Sir John Murray as 1 is to 7; and Scott[2] as 1 is to 5. The cannonading performed upon an iceberg by H.M.S. "Challenger,"

[1] Rink: Danish Greenland, London, 1877, p. 358.
[2] Scott: Geog. Journ., April, 1905, p. 356.

showed that the density is not uniform. Our experience upon the Ross Ice-sheet proved that normal glacier ice could be capped by any thickness of *firn* or loose snow; and therefore of two bergs with equal volumes immersed, if the visible part of one consisted wholly of snow and that of the other wholly of ice, the ratios of the visible to the submerged portions would be widely different. Again, the temperature and salinity of the sea-water have some effect in buoying up the ice, but this may be neglected. However, the aeration of the ice varies greatly, but for normal glacier ice Helland gives 0·886 as the specific gravity, while my results show a specific gravity of 0·83. Therefore, in Antarctic sea-water with an average density of 1·025 grammes per cubic centimetre, glacier ice would float with four parts immersed and one visible. This figure agrees closely with the results of Von Drygalski and Captain Scott obtained by actual measurements at glacier snouts. The greatest ice-cliff observed by

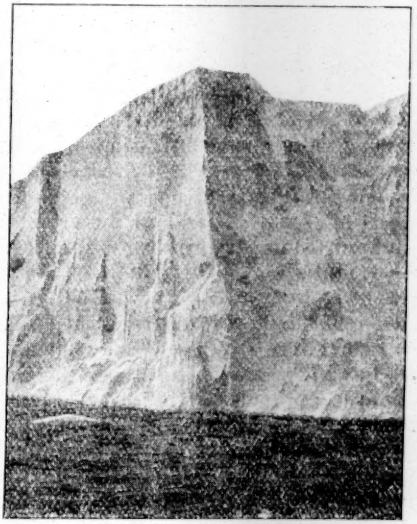


Fig. 2.—The edge of the Ross Ice-sheet near the point where it is thickest.

the staff of the "Discovery" was the edge of the Ross Ice-sheet floating in the vicinity of Cape Crozier. The height here was 240 feet and the depth of water 460 fathoms. As the surface here was unbroken and the cliff-face uncrevassed (see Fig. 2), it is hardly likely that this extreme thickness was produced by pressure as Professor Schwarz [1] suggests.

The question as to the limit of 1,600 feet being exceeded depends, as Professor Schwarz rightly points out, upon the temperature of the lower surface of the ice being below its melting-point. As far as I remember, the figure 1,600 feet is the height of a column of ice

[1] Schwarz: Geol. Mag., Dec. V, Vol. III, March, 1906, p. 122.

which would by its own pressure liquefy its sole if the temperature were 1 degree Fah. below its normal melting-point, and therefore the limiting thickness of 1,600 feet is far *above* the maximum for ice resting on land at the melting-point of ice.

At the "Discovery's" Winter Quarters, under the shadow of Mount Erebus, latitude 77° 51′ S., longitude 166° 45′ E., the mean annual temperature was —4·6° F.,[1] and hence the point where a temperature of 32° F. would be found must be below the surface. Whether this point be well below the sole of the thickest ice has not been determined, but as the glaciers are practically stationary their ice must be out of reach of this temperature. A series of observations of the temperature of glacier ice at fixed depths was made. The observations were commenced in April, after the temperature of the ice had begun to fall, and extended throughout the following Winter and Summer, until the month of February, when the ensuing fall of temperature due to the increasing cold began. The highest temperature recorded at a depth of six feet was —9° C., and the lowest —24·4° C.

The large difference between the maximum and minimum temperatures recorded below the ice and the lag caused by the six feet of ice would seem to show that the point which is not influenced by seasonal variations is still deeper down. Now if we take a value once adopted by a British Association Committee for the earth's mean temperature gradient, we get a rise of 1° F. for every 64 feet increase of depth. Therefore, for a rise of 36 Fahrenheit degrees (our mean annual temperature below the freezing-point) the 32° F. isothermal would be at least 2,300 feet below the surface. On the inland ice Captain Scott's observations show temperatures of 10°, 15°, or even 20° below those registered simultaneously at Winter Quarters. Therefore the mean annual temperature on the inland ice would be below the mean at Winter Quarters and the 32° F. isothermal surface proportionally lower down.

Von Drygalski's results point to the same conclusion, but it must be remembered—(*a*) that some of his temperatures were recorded from crevasses which were open to the air and to water during the Summer thaw; (*b*) that in Greenland during Summer the air temperature remains above the freezing-point of ice for several weeks, and often rises 8 or 10 degrees above that point.

Professor Schwarz does not seem wholly in favour of the view that a warmer climate in the Antarctic would produce a thickening of the ice-cap, sufficient to exceed the physical limit.[2] The German Antarctic Expedition and other earlier expeditions which remained near the Antarctic Circle record a great snowfall as compared with that experienced by the British Expedition in higher latitudes.

[1] All the temperatures quoted are our uncorrected values. Reference should be made to the "Discovery" Reports on Geology and Meterology, which are to be published by the British Museum (Natural History) and the Meteorological Office respectively.

[2] Tyndall: "Heat a Mode of Motion," 1898, 11th edition, p. 231 ff.; "The Forms of Water," 1892, 11th edition, p. 154.

The amount of snow on South Victoria Land was observed to diminish in quantity as the "Discovery" steamed south along the coast, and in latitude 77° South the glaciers were found to be retreating. By means of graduated stakes (snow-gauges) and blocks of ice exposed to the air throughout the year, it seems to be established that the ablation of the ice is greater than the precipitation. The mean temperature for the two Summer months was −4·3° C., and it was only when the sky became overcast and the air temperature rose a degree or two above the mean that any measurable quantity of snow fell.

It is as evident to those of us who have been in high latitudes that the isotherm of 0° C.[1] (which is near the Antarctic Circle) is an effective barrier to the transport of snow to higher latitudes; as it is evident to those who have been on both coasts of Ireland, on the south coast of Africa and the Karroo, that the mountains are a shield and cut off the rain from districts further inland. Professor Schwarz uses the argument that a high temperature during maximum glaciation will consequently produce more running water, and

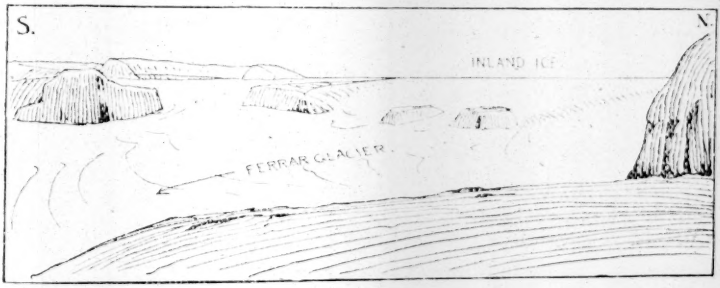


Fig. 3.—The inland ice falling down between nunataks from the inland plateau. From a sketch by H. T. Ferrar, greatly reduced.

attributes the deepening of glaciated valleys, not to the greater power of the ice, but to that of sub-glacial streams.[2] If this is so, then the deeply incised valleys of the Royal Society Range, with their stagnant glaciers, would afford additional evidence that a rise in temperature, and consequently a southerly migration of the zone of maximum precipitation, had taken place at some former period.

In his article, p. 123, Professor Schwarz says Scott found the highest points to sink below the horizon directly the level ice-cap was reached. Scott expressly says, on p. 414 of his narrative—"when we reached the interior plateau at a height of 8,900 feet we observed nunataks to the north standing above our own level." Mount Lister is given as 13,000 feet high, and stands on the edge of the plateau. The accompanying Fig. 3 is a sketch of the South Victoria Land ice-sheet as it falls together and becomes moulded into the Ferrar Glacier. The height between the graded surface of the

[1] Buchan: "Challenger" Reports, Physics and Chemistry, plates.
[2] Garwood: Q.J.G.S., vol. lviii, pl. xl.

glacier and the plateau is nearly 1,000 feet. Scott points out that this land at the back of the Royal Society Range appears to be higher than that to the north or to the south. This means that he thinks the Royal Society Range is the end of an elevated mass of land, with its length transverse to the coastline (i.e. east and west), and that a measure of the thickness of the Antarctic Ice-cap on this elevated transverse ridge would therefore be inaccurate.

That Captain Scott found it approximating to the physicists' maximum limit of 1,600 feet, no doubt is a very strong argument in favour of the view that the physicists' extreme limit is never exceeded. But when I repeat that the glaciation of South Victoria Land is approaching to a minimum, and that all glacialists require a great thickness of ice to explain the phenomena which they have described, I think it will be conceded that—(*a*) any thickness of ice may be accumulated so long as the loss by ablation, melting, and discharge is less than the gain by precipitation; (*b*) that the facts noted above are more in harmony with the glacialists' requirements than with Professor Schwarz' contention that the physicists' theoretical maximum of 1,600 feet cannot be exceeded.

II.—On the Interglacial Question.

By T. F. Jamieson, F.G.S.

A GREAT difference of opinion seems to exist among geologists, not only in Britain but also in other countries, in regard to the supposed occurrence of warm Interglacial periods during the age of ice. Those who incline to the views propounded by Adhemar and Croll as to the causes which produced the extraordinary climate of that time naturally look for alternations of cold and warm periods.

Precession of the equinoxes and variations in the excentricity of the earth's orbit are astronomical facts which must have had their influence, and the changes they might bring about in the direction and force of ocean currents, to which Croll attributed so much importance, have also to be considered. These astronomical causes and their accompaniments are not to be ignored, but their precise effect upon the climate of the period in question is still a matter of much uncertainty and one in regard to which our knowledge has made very little progress.

Mr. Lamplugh, in his recent address to the Geological Section of the British Association, lays much stress on the absence of any clear evidence of warm intervals or even of one such interval in the British Islands, and as no one is better acquainted with the drift beds of England his opinion must have much weight.

It seems to me that there is one important circumstance which may have led to this obscurity and which has not received the consideration it deserves, and that is the persistence of the vast masses of ice which accumulated during the intensity of the glaciation, and the consumption of heat required to dispel them. The Scandinavian glacier alone seems to have spread out in some

directions fully 1,000 miles, and much of its thickness must be reckoned in thousands of feet. The North American ice perhaps attained even greater proportions. Just think of the amount of heat and the time it would take to thaw such masses. There is a huge difference between snow and ice in this respect. Snow, especially when newly fallen, thaws rapidly, but ice does not. It melts with extreme slowness, and so long as the thaw was going on and much of the ice-sheet remained, the temperature of the air in Northern Europe and America would not rise to any great degree. The accumulation represents a storage of cold during thousands of years, and the probability seems to be that the returning heat brought about by the precession of the equinoxes would not always be able to dispel the vast masses of ice left on the land by the preceding period of glaciation. In short, the heat would all be spent in but a partial melting of the glacial covering. Consequently the temperature in many places would never rise so far as to cause a complete reversal of climate, and thus no clear evidence of an interglacial warm period would be found, but merely indications of a large retreat of the ice-front. Croll, it is true, did not take this view of the matter, for he conceived that the reversal of climate would be complete, and that the ice would wholly disappear from one hemisphere when the other was under glaciation. In this, however, I think he may have been mistaken. At any rate, we have no certainty that such would be the case.

Now, in the north of Scotland we can show that the basin of the Moray Firth was at one time filled with ice to such an extent that the right flank of the mass flowed eastward along the coast of Moray and Banff and then wheeled round the corner of Aberdeenshire, where it appears to have surmounted a hill 769 feet high; while its left flank in like manner turned round over the lower part of Caithness, overflowing hills there some hundreds of feet in height, and producing the shelly boulder-clay of that district.[1] All this implies a thickness of ice in the basin of the firth to be measured by thousands of feet. Now we have further evidence that this great mass of ice afterwards disappeared, and that sea-water inhabited by mollusca of a northern type occupied the basin up to the very top at Inverness. The Northern and even Arctic character of many of the species found in these shell-beds seems to show that although an enormous amount of heat must have been long in action to dissipate such a mass of ice, yet this heat was not sufficient to introduce a decidedly warm climate, at any rate so far as the temperature of the sea-water was concerned; nor has any evidence as yet been obtained in the district to indicate a warm temperature on the land. This episode of an interglacial occupation of the Moray Firth basin by sea-water inhabited by mollusca of a northern type was afterwards followed by a return of the glacier in great force, which destroyed the shell-beds and covered them with heavy masses of boulder-clay, as we see at Clava and elsewhere.

[1] Journal of the Geol. Soc., vol. lxii, p. 13, Feb., 1906. T. F. Jamieson on the Glacial period in Aberdeenshire and the Southern border of the Moray Firth.

Here, then, it seems to me we have a case in point, affording good evidence of an interglacial period with abundance of heat, and yet not enough to cause a decided reversal of climate, but only sufficient to clear out the heavy mass of ice which filled the basin of the Moray Firth. Such a result certainly could not have been accomplished without the expenditure of an enormous amount of heat, which in districts where there was no ice to dispel would have produced a decidedly warm climate. During the thawing of the ice and its reduction into ice-cold water the air would remain cold, and not until the ice had completely disappeared would the climate become genial. Before this could happen in the Northern districts the interglacial spell of warmth might be passing away, and hence no genial climate would result.

Ellon, Aberdeenshire.

III.—On the Origin of certain Laterites.

By Malcolm Maclaren, B.Sc., F.G.S.

THE various views put forth prior to 1893 to account for the origin of Indian laterites have been clearly and sufficiently discussed in Oldham's edition of Medlicott & Blanford's Manual of the Geology of India (pp. 369 et seq.). Since that year the only contribution of importance to the literature of lateritic genesis in India is a paper by Mr. Thos. H. Holland, F.R.S., the present Director of the Indian Geological Survey,[1] having for its text the conclusions of Bauer.[2] In it the author suggested that laterite might owe its origin to "some lowly organism," but no sufficient data were advanced in support of the suggestion. Bauer's specimens indicated a certain amount of dehydration in laterites, and this fact, together with the absence of hydration products from certain peridotites in Southern India,[3] was deemed to indicate a general dehydration for the bauxitic laterites of the Deccan. The gibbsite ($Al_2O_3, 3H_2O$) of laterite was supposed to be dehydrated to diaspore (Al_2O_3, H_2O), and it was assumed that "this irregular loss of water is probably the cause of variation in bauxite."[4]

To account for the energy necessary for dehydration the ingenious theory of the possible superiority of "crystalline affinity" over "chemical affinity" was developed (loc. cit., p. 69), and the conclusion was drawn that "limonite and gibbsite must be regarded as unstable at tropical temperatures."[5]

Of late years valuable analytical researches on the constitution of laterite have been made by Dr. Warth,[6] who may justly be considered

[1] Geol. Mag., Dec. IV, Vol. X (1903), pp. 59–69.
[2] "Beiträge zur Geologie der Seychellen": Neues Jahr. für Min., vol. ii (1898), p. 163.
[3] Geol. Mag., Dec. IV, Vol. VI (1899), pp. 31, 542.
[4] Ib., Dec. IV, Vol. X (1903), p. 65.
[5] See, however, Geol. Mag., Dec. IV, Vol. X (1903), p. 139.
[6] Min. Mag., vol. xiii (1902), p. 172. Geol. Mag., Dec. IV, Vol. X (1903), p. 154; ib., Dec. V, Vol. II (1905), p. 21.

the pioneer in the investigation of the nature of Indian laterites, though their aluminous character had years before been suggested by Mallet.[1] Various analyses have also been made from time to time in the laboratory of the Geological Survey of India.[2]

A comprehensive genetic theory of lateritic deposition must reasonably account for any or all of the following features:—

(1) The restriction of the deposition of laterites, both geographically and in altitude.
(2) Their general superficial occurrence.
(3) Their internal structure—porous, vesicular, pisolitic, or concretionary.
(4) Their peculiar composition as regards—
  (*a*) The essential aluminous, ferruginous, or manganiferous hydrates or oxides.
  (*b*) The general presence of titanium dioxide.
  (*c*) The general absence of kaolin or silica.

The present writer's experience of Indian laterites is not geographically extensive, but is, nevertheless, fairly varied, including as it does the 'high-level' laterites of Chota Nagpur, Bengal, of the Southern Maratha country on the edge of the Deccan Trap, and of the Western Ghats, west of Belgaum, and the 'low-level' laterites of the Portuguese territory of Goa on the west coast of the peninsula. There is no necessity in this place to describe the physical aspect of laterite. A general description may be found in Oldham's edition of Medlicott & Blanford's Manual already quoted, and for fuller details the reader may be referred to the papers of Newbold[3] and of Lake,[4] which, despite the age of the former, remain by far the best descriptions of 'high-level' and of 'low-level' laterite respectively.

It was an examination of sections of the lateritic manganese deposits of Talevadi, on the edge of the Western Ghats and overlooking the Goa peneplain 2,500 feet below, that first suggested the theory of lateritic genesis presently to be outlined (see Fig. 1, p. 538). There, pits in search of manganese expose the laterite in process of formation and give sections of some 30–40 feet in depth. The bottom of a typical section shows a white decomposed friable sandy rock which, from exposures elsewhere, is regarded as a decomposed biotite-quartz schist. This passes upward without any abrupt change through a buff sandy clay to a reddish buff, soft rock containing small indistinct ferruginous secretions and minute manganese nodules. As the surface is approached the rock gradually acquires depth in colour, while the contained manganese secretions become larger and better defined until, at the surface, they are 2–3 feet across with a like depth. With increase of ferruginous content, the rock becomes so hard that, at the surface, it is often necessary to use explosives to disintegrate it. A few

[1] Rec. Geol. Surv. India, vol. xvi (1883), p. 113.
[2] Ib., vol. xxxiii, p. 178.
[3] Journ. As. Soc. Bengal, vol. xiii (1844), p. 990.
[4] Mem. Geol. Surv. India, vol. xxiv (1890), pt. iii, p. 47.

feet below it can be cut with a spade. Through the manganese secretions there ramify veinlets of gibbsite—Fig. 1 (1)—much of it of metasomatic replacement. It is, consequently, the last deposited product. In the immediate neighbourhood of the manganiferous laterites the writer found small areas of high-grade pisolitic bauxites. There are, therefore, in this neighbourhood all the ordinary forms of laterite—ferruginous, aluminous, and manganiferous. The last has not generally been distinguished, but it cannot be dissociated genetically from the other two.[1]

The low-lying country of Goa between the coast and the Deccan plateau furnishes extensive deposits of 'low-level' laterite, partly

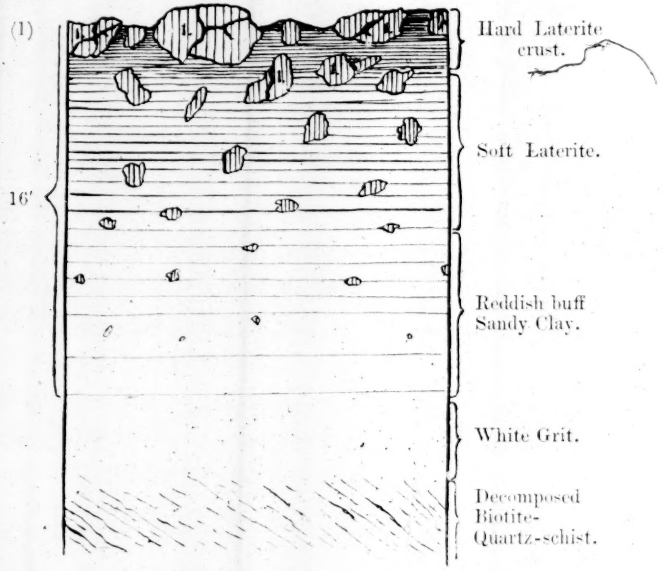


Fig. 1.—Typical Section of Laterite, Talevadi, Belgaum.
(1) Psilomelane with gibbsite veinlets.

detrital and partly secretionary in origin. Examination of this area elicited no further data than were collected by Lake for a similar coastal region further south in Malabar.[2] Two main forms, the vesicular and the pellety, were distinguished. The latter is often partly derived from the erosion of the former, but its final consolidation and cementation is due to the same agencies that gave rise to the first or vesicular form.

The rainfall of the edge of the Western Ghats and of the Goa country ranges from 120–180 inches in the year, but falls almost

[1] See, however, Mallet, Rec. Geol. Surv. India, vol. xvi (1883), p. 117; Bose, ib., vol. xxii (1889), p. 225.
[2] Mem. Geol. Surv. India, vol. xxiv (1890), pt. iii, p. 17.

entirely from June to October, a period of four months. At Karwar, for example, rain has fallen on 72 successive days, and yet the total number of rainy days in the same year has been no more than 120. The average shade temperature of the same region is a trifle below 80° F., with a monthly range of from 75° to 84° F. With such rainfall and temperature vegetation is naturally luxuriant, especially in the lower-lying regions. During the cold weather, the dry field season of India, little or no idea of the moisture precipitation of these regions can be gained. Especially is this the case on the higher lands. The Atli laterite plateau, north of Castle Rock, when seen in January was a dry and arid, hopelessly waterless, area. Fortunately the exigencies of *shikar* took the writer over the same area in late July. The plateau, so far as it could be seen for the driving rain and mist, was then, to outward appearance, a morass, though, through its thin covering, one thankfully felt the hard laterite crust beneath. Periods of dessication and saturation are thus very well marked.

Regions of abundant rainfall in tropical climates are well wooded, and humus being always abundant the proportion of carbon dioxide in solution in the soil is correspondingly high. Boussingault and Lewy[1] show that, in a temperate climate, the air of a soil rich in humus may contain more than one hundred times as much carbon dioxide as atmospheric air. Considering the greater rapidity of decay and chemical change in tropical regions, this factor is likely to be greatly exceeded in India. The amount of silica dissolved in underground waters may also be taken as a measure of the amount of carbon dioxide in solution, and Struvé[2] has shown that the amount of silica thus dissolved is much greater in regions of abundant vegetation than in those where it is absent or sparse.

There is no need in this place to discuss at length the action on silicates of waters containing alkaline carbonates and carbon dioxide in solution. Bischoff, fifty years ago, suggested that the silicates were decomposed by these agencies, and Kahlenberg and Lincoln[3] have recently shown that the resulting silica separates in the form of colloidal silicic acid.

The normal weathering change of felspars in temperate regions is undoubtedly to kaolin, as indeed is sufficiently indicated by the analyses of the Rowley Regis dolerite by Dr. Warth[4] in connection with this very subject. The general equation may be represented thus: taking, say, albite as a typical felspar, $2\,Na\,Al\,Si_3\,O_8 + 10\,H_2\,O + C\,O_2 = H_4\,Al_2\,Si_2\,O_9 + Na_2\,C\,O_3 + 4\,H_4\,Si\,O_4$. Where abundant carbonates are produced, as is apparently the general case in humid India, the change is not to kaolin but rather to a sericitic form:[5] thus, $3\,(Na\,K)\,Al\,Si_3\,O_8 + 10\,H_2\,O + C\,O_2 = (Na\,K)\,H_2\,Al_3\,(Si\,O_4)_3 + (Na\,K)_2\,C\,O_3 + 6\,H_4\,Si\,O_4$; and herein probably lies the explanation of the general absence of kaolinite from the purely

[1] Quoted by Merrill: "Rocks, etc.," p. 178.
[2] Pogg. Annal., vol. vii, pp. 341, 429.
[3] Journ. Phys. Chem., vol. ii (1898), pp. 77–90.
[4] Geol. Mag., Dec. V, Vol. II (1905), p. 21.
[5] Lindgren: Trans. Amer. Inst. M.E., vol. xxx, p. 614.

superficial deposits of India, though, in the form of lithomarge or halloysite, it occurs in abundance at shallow depths.[1]

The equation most fitted to Indian conditions is, however, one more in accordance with the general conclusions of Kahlenberg and Lincoln, and one also indicative of more energetic chemical action in the presence of abundant carbon dioxide. Here the silicates are completely decomposed, all the silica passing off as colloidal silicic acid. The action may, and doubtless often does, take place through an intermediate sericite or lithomarge stage, but the simplest expression is adopted.

$$2\,NaAlSi_3O_8 + 15\,H_2O + CO_2 = Al_2(OH)_6 + Na_2CO_3 + 6\,H_4SiO_4.$$

By this process of carbonation aluminium hydrate may similarly be derived from any other of the felspar family, from the micas, from the felspathoids, from the scapolites, and from many of the minerals of contact metamorphism. We have, therefore, no difficulty in finding an origin for all the aluminous hydrates of laterites. By carbonation also ferrous and probably manganese carbonates in like manner result from the decomposition of the ferro-magnesian silicates. It is, of course, not insisted that any of the resulting compounds are definitely formed, but rather that they are merely potential salts in ionized solutions.

So far the equations given are in accordance with numerous data and with generally accepted principles. The origin of the ilmenite and titanic acid met with in most laterites is by no means so clear, but it may at once be conceded that their manufacture is certainly a task from which even the stoutest-hearted of bacteria might recoil without incurring the odium of pusillanimity. Data concerning the alterations of titaniferous minerals are scanty. Rutile and ilmenite may, as suggested by Van Hise,[2] be derived from original sphene:

$$(1)\quad CaTiSiO_5 + CO_2 = CaCO_3 + TiO_2 + SiO_2\,;$$

$$(2)\quad TiO_2 + FeCO_3 \rightleftarrows FeTiO_3 + CO_2\,:$$

the last equation being reversible. A careful examination of thin sections failed to reveal any leucoxene in the laterite, but this form of titanic acid, unless under exceptional conditions, would be distinguishable with great difficulty from the bauxite matrix.

Titanic acid is, however, by no means confined to laterites and bauxites among superficial deposits. The extensive soil analyses of Dunnington[3] showed its presence in all the 72 soils gathered from many parts of the world and examined by him. The average percentage of TiO_2 obtained for the whole series was ·95. When to this normal percentage is added that collected by the exceptional facilities enjoyed by laterites for selective segregation, the high percentage contained by many bauxites is perhaps no matter for surprise.

We have thus derived by the agency of carbonating waters from

[1] [A more satisfactory formula to represent the process of sericitization in alkali felspars is that given by Van Hise (Metamorphism, p. 254): $3\,KAlSi_3O_8 + H_2O + CO_2 = KH_2Al_3Si_3O_{12} + 6\,SiO_2 + K_2CO_3$.—Edit. Geol. Mag.]

[2] U.S. Geol. Surv., Mon. 47 (1904), p. 227.

[3] Amer. Journ. Sci., vol. xlii (1891), p. 491.

underlying or adjacent rock masses, in solution, and probably in ionized solution, all the materials essential to the formation of laterite. There is now to be considered the machinery necessary to bring it to its resting-place at the surface. The conditions of successive dessication and saturation in regions of lateritic growth have already been indicated. During the former period the motion of ground waters is always from the region of greater to the region of lesser humidity, or, in this case, upward to the surface. Upward transmission is effected entirely by molecular attraction, resulting where conditions are favourable in capillary motion, that directly due to dessication being intensified by the needs of forest rootlets. The potency of capillary transmission may be gathered from the experiments of King,[1] who showed that molecular attraction, acting in capillary openings in a porous rock, was capable of raising from a depth of four feet an amount of water equivalent to an annual rainfall of 63·85 inches. The larger tubes anastomosing in laterite have often been described, and microscopic examination of both ferruginous and aluminous laterites discloses numerous tubular openings both capillary (·0002–·508 mm.) and super-capillary (exceeding ·508 mm.).

With the approach of ground waters to the surface and their consequent super-saturation in the dessicated region, separation of the contained solids takes place, at first, it would seem, on the tube walls and around pisolites. The minute tubes in the matrix of most laterites render it probable that some moisture passes entirely through the laterite crust and that a slight deposition takes place on the laterite surface exposed directly to the atmosphere, but by far the greatest amount of deposition must take place on the under side of the hard surface crust. During the dry season the whole of the contained load of the upward moving waters is thus deposited. There is at that time in the dessicated rock and soil but little metasomatic replacement, though segregation may readily take place as the solutions become more and more concentrated. During the period of saturation, however, all soluble constituents deposited during the previous dry season are dissolved and carried away. The insoluble constituents are thus left to obey in a moisture-saturated soil their natural laws of growth. They are further segregated, and deposited in most cases as fine bands around already formed concretions. Segregative action is well marked in the Talevadi sections, the lower zones, nondescript in colour and composition, passing upwards into well-defined ferruginous laterite, manganese ore (mainly psilomelane), pure bauxite, and gibbsite.

In the ordinary course of formation of laterite a surface crust is first formed which increases in purity, hardness, and depth with every successive dry season. The depth and hardness of the hard unaltering layer may, therefore, in areas in which laterite is still being formed, be some measure of the age of the deposit. All stages are met with. At Talevadi the hard crust is two to three feet thick, in the Central Provinces it is often 20–30 feet in

[1] U.S. Geol. Surv., 19th Ann. Rep. (1899), pt. ii, p. 85.

thickness, while in Goa it may often be cut from the surface with a spade.

From the foregoing it is evident that laterite must be regarded, not as the direct product of the decomposition of a rock *in situ*, but essentially as the *replacement* of such a decomposition product, for though the ground waters may have derived their mineral content from the underlying rock, they may also have brought it from sources widely separated. A laterite may thus result from the individual or combined decomposition of basalts, gneisses, or schists, and there may, in its hardened upper surface, be no particle of the rock whose former place it now occupies.

The assertion of a previous writer[1] that there always is a sharp change from the soft decomposition product beneath laterite to the absolutely fresh rock below is not borne out by field sections. Such sharp changes certainly do occur, but they are exceptional, and occur only where the laterite is 'low-level' recemented detritus,[2] or occasionally where laterites overlie difficultly decomposable beds in the Deccan Trap. In the latter case, the downward rate of weathering of the trap is inversely as the lateritization, since, generally speaking, with increase of the latter, flow and ingress of surface waters, the only rapid weathering agent in the case of a solid homogeneous basaltic lava, are restricted. A sharply defined boundary, therefore, indicates the horizon at which the downward lateritization finally overtook the downward weathering.

Under the replacement hypothesis, all substances dissolved in the ground waters should be brought to the surface, and some explanation of the absence of silica from lateritic deposits is, therefore, necessary. As already seen, the silica formed is carried away as colloidal silicic acid, on the instability of which it is unnecessary to dwell. When not decomposed by simple "chemical after-effect," it is probable that the humic acids of the upper portion of the zone of weathering are competent to change its state and to precipitate it. Precipitation is always liable to take place in a region where the laws of mass-mechanical action—to which silica in solution is peculiarly subject—may operate. That much of the silica formed by carbonation is thus deposited we have evidence even in the lateritic regions of the Central Provinces, where both the Lametas (Upper Cretaceous) and the underlying crystalline rocks have been so thoroughly silicified as to render it often impossible to determine whether an area is to be mapped as Upper Cretaceous or as Archæan.[3] Limestones (both Lameta and Archæan), gneisses, and pegmatites are there so completely replaced by chert that only by the indications of the original structure can they be differentiated.

Though the foregoing explanation of the absence of silica is neither full nor satisfactory, yet the replacement hypothesis is not thereby vitiated, since, whatever the explanation, the facts remain that everywhere immense quantities of silica are being dissolved.

[1] Geol. Mag., Dec. IV, Vol. X (1903), p. 69.
[2] Lake: Mem. Geol. Surv. India, vol. xxiv (1890), pt. 3, p. 30.
[3] L. L. Fermor: Rec. Geol. Surv. India, vol. xxxiii (1906), p. 173.

and that nowhere, except in the thermal regions, are siliceous deposits brought to be deposited at the immediate surface of the earth.

The peculiar disposition in altitude of Indian laterites has always presented a difficulty to geologists, and many have called to their aid lakes, or even the sea, to account for the general horizontality noted. The 'high-level' laterite covers flat-topped hills, which may range from 2,000 to 4,700 feet above sea-level, and higher still on the Nilghiris, while the 'low-level' form occupies the eastern and western peneplains. In both upper and lower areas, however, adjacent laterite caps may occur at different levels,[1] indicating either disconnected deposits or differing age. In the region of the Deccan Trap, the widespread horizontality of the laterite is merely an expression of that of the Trap beneath (loc. cit., p. 261), which has filled up the inequalities in the surface of the older rocks. A consideration of the conditions of lateritic formation will show that only on level or approximately level surfaces can laterite form. Its growth is exceedingly slow, and only the surfaces of plateau basins or plains are stable for a sufficient length of time to permit of growth. Even a moderate slope changes its surface cover rapidly in a region of excessive rainfall. Again, it is only on an approximately level surface that the continued moisture saturation necessary for the solution of the soluble constituents and for the rearrangement of the deposited salts may be obtained. Judging, therefore, by the conditions under which laterite is considered to be forming at the present day, the 'high-level' laterite capping hills represent the level of ancient upland plains, or more probably flat broad basins, which abutted against or were enclosed by hills. It is the general recognition of the horizontality of many deposits that has given rise to the hypothesis of lacustrine sedimentary origin, an origin thought to be supported by the concretionary structure before noted. Concretionary or pisolitic structure, however, as a general rule, does not arise under open water conditions, but is characteristic rather of loosely coherent muds, clays, or moist sands. An analogy with the lake iron-ores of Sweden has been sought by some writers, and the presence of limonite-secreting bacteria in those deposits has probably suggested the Indian bacterial theory.

During the progress of denudation, the high hills in the neighbourhood of the basins, being unprotected by laterite, have disappeared, and their place is now occupied by valleys. Many of these ancient basin floors are situated in what are now dry regions, and it is probable in such cases that the vanished hills attracted the necessary amount of moisture. For example, in the neighbourhood of the laterite-capped Kappat Guda (3,007 feet), east of Dharwar, the rainfall is no more than 25 inches per annum, and no laterite is being formed at the present day. This region, lying at about the same height above the sea-level as the edge of the Western Ghats, incidentally illustrates well the nature of the surface products

[1] Oldham: in Medlicott & Blanford's Manual of Geol. India, pp. 374 et seq.

generated in areas of deficient moisture. Its soil is crowded with 'kankar'—small irregular concretions of carbonate of lime—which may, in the stream beds, form a calcareous tufa, while the rivulets that do run in the dry season through the black cotton soil are bitter with alkaline salts. These are exactly the products removed in regions of abundant rainfall.

Except when the humidity is great, the laterite crust supports a very scanty vegetation, and, even in humid areas, it is probable that much of the carbon dioxide essential for carbonation is derived from the decaying humus on the hill-sides above the laterite basins. The older laterites on the hill-tops are devoid both of vegetation and of soil.

The chemical aspect of the Indian aluminous and ferruginous laterites has been well developed by the analyses of Dr. Warth.[1]

Some little attention has been paid by the present writer to the nature of the minerals present. The bauxite, especially selected for examination since it promised to yield the most conclusive results, was one from Katni, Jabalpur district, which had been analysed in the Geological Survey Laboratory,[2] as follows:—

Al_2O_3	65·48
Fe_2O_3	3·77
H_2O	18·32
Moisture	1·06
SiO_2	0·38
TiO_2	11·61
MgO	trace
	100·62

The molecular ratio of Al_2O_3 to H_2O is lower (1 : 1·58) in this specimen than in any other analysed, and for this reason it was expected to show more clearly than any other the presence of diaspore, should the assumption of Warth and others, viz. that bauxite is a *mixture* of gibbsite and diaspore, be correct. Neglecting, as Warth has done, and with sufficient reason,[3] the consideration of the water due to possible limonite in the specimen, the foregoing ratio of 1 : 1·58 represents 29 per cent. gibbsite and 71 per cent. diaspore. It was, therefore, considered probable that a separation might be effected with a heavy solution, the specific gravity of gibbsite being 2·4 and of diaspore 3·4. Carefully and finely ground bauxite was treated with Sonstadt solution of 3·07 s.g. All except very fine black grains (ilmenite) floated. The specific gravity of the specimen as a whole was taken, and gave incidentally an excellent illustration of the porous nature of bauxite. A large fragment was soaked for a day in water with gentle heating, and gave a result of 2·487. Individual concretions from the same specimen gave 2·53, while the mean of three determinations of the fine powder gave 2·81. The last is taken as the true specific gravity of the Katni specimen.

[1] Geol. Mag., Dec. IV, Vol. X (1903), p. 158.
[2] Rec. Geol. Surv. India, vol. xxxii (1849), p. 179.
[3] Loc. cit. sup., p. 155.

The chemical analysis shows that at least 15 per cent. of the mass has, in the form of ilmenite and possible rutile, a specific gravity of more than 4·3. The remaining 85 per cent., therefore, has a specific gravity of not less than 2·65. But an intimate mixture of 71 per cent. diaspore and 29 per cent. gibbsite should have a specific gravity of 3·03. Rough though the calculation is, it is nevertheless sufficient to show that the two lines of deduction are hopelessly conflicting, and it must either be assumed that diaspore is not present or that the monohydrate, if present, is in a form physically different from diaspore. Additional evidence against diaspore lies in its absence from all thin sections examined.

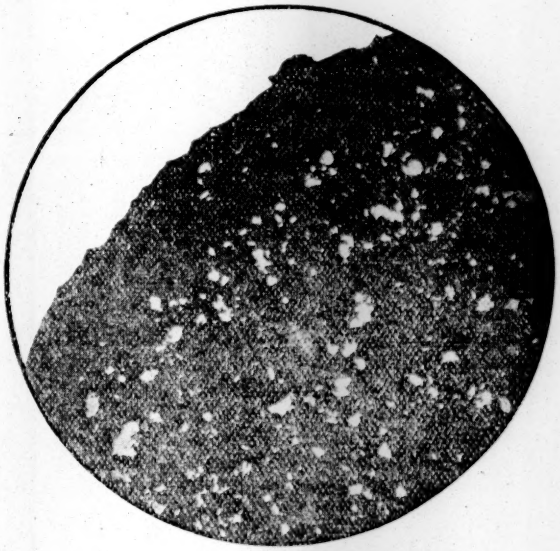


Fig. 2.—Thin section of portion of a Bauxite concretion, Katni, Jabalpur, showing gibbsite crystals (colourless) in bauxitic (dark) groundmass.

A typical thin section of a concretion from the Katni rock throws considerable light on the structure and internal characters of bauxite (Fig. 2). The mass of the rock is made up of white opaque bauxite with a well-defined banded structure near the exterior of the concretion. Scattered through the interior and avoiding the outer band, are numerous irregular areas of gibbsite in rosette-like aggregates. Dispersed everywhere irregularly through the interior of the section, but disposed in more or less linear arrangement in the outer band, are numerous minute black and brown specks, too small, indeed, to be determined with ease or accuracy. The black grains are, however, almost certainly ilmenite, while the brown granules may be rutile, but, from comparison with other sections, are thought to be more probably the clove-brown micaceous ilmenite.

A consideration of the disposition of the gibbsite indicates clearly

that it is being formed at the expense of the bauxite, and, indeed, the process may be traced in the section in all its stages. A slight clearing takes place in the opaque mass, and an irregular translucent microcrystalline area is formed. In this area, tiny flecks of gibbsite are developed, gradually coalesce, and finally fill the whole area. This process of crystal growth is especially well marked along the internal edge of the concretionary border, where the gibbsite is extending outwards into the newly accreted bauxite. That bauxite is being converted to gibbsite, and not the reverse, is confirmed by the occurrence of banded gibbsite on the walls of the pores that ramify through the mass.

The evidence of thin sections, therefore, shows that the change in laterites, so far from being one of dehydration to diaspore, as postulated by Holland,[1] is one of hydration to gibbsite. This conclusion is supported by the occurrences of gibbsite found by Messrs. Warth, Fermor, and the writer in widely separated parts of India, and all these show that, at least under the generally prevailing, comparatively humid Indian conditions, gibbsite is the stable hydrate of alumina. Strong negative evidence to the same effect lies in the fact that diaspore has not yet been recorded from India. As a matter of fact, the evidence against hydration quoted by the above writer, being drawn mainly from the petrological characters of certain rocks in the Salem and Coimbatore districts, is considered by the present writer to be inapplicable to the more humid parts of India. The average annual rainfall for Salem is but 39·20 inches per annum, while that for Coimbatore is even less (21·10 inches). At both stations rain fell during ten months of the year 1904. There is thus little opportunity for hydration, while dehydration might well be effected. But the argument derived from such a dry region can obviously not be applied to the lateritic deposits of the Western Ghats with their rainfall of 120–180 inches in four months of the year.

Finally, the conclusions to which the writer has been led in connection with laterite are the following :—

1. Lateritic deposits are restricted geographically, because they require for their formation—
   (*a*) Tropical heat and rain with concomitant abundant vegetation.
   (*b*) Alternating wet and dry seasons.
2. Their restriction in altitude is only apparent. Their present lines of altitude merely mark ancient or existing basin floors or plains.
3. They are derived from mineralized solutions brought to the surface by capillarity, and are essentially replacements (either mechanical or metasomatic) of soil or of rock decomposed *in situ*, or of both.
4. In the humid regions of India the tendency of change in laterites is towards hydration and not towards dehydration.

[1] Geol. Mag., Dec. IV, Vol. X (1903), p. 65.

The foregoing replacement hypothesis would appear to supply a fairly reasonable explanation for all the eccentricities of laterite. When it was first developed by the writer, it was thought to be entirely novel, but investigation of the literature of the subject has shown that several writers have suggested the alternation of wet and dry seasons as a predisposing cause [1]; while Hislop [2] says that "the ferruginous matter coming up from among the metalliferous strata, might, by the agency of water, have impregnated every decaying rock on the surface, which, with the subsequent infiltration of rain, would then present the appearance of laterite, as we now find it"!

IV.—Notes on the Operculate Madreporaria Rugosa from Yass, New South Wales.

By A. J. Shearsby.

(PLATE XXVI.)

THE town of Yass, N.S.W., is situated on the Southern Railway about 190 miles from Sydney. It is the centre of one of the most picturesque districts to be met with on the journey from Sydney to Melbourne. The surrounding country is a veritable geological and palæontological paradise for the collector, who may depend upon turning up some new and interesting specimens every trip he takes to the district. The town itself is built on the Upper Silurian rocks, which about two miles distant, at a bend in the Yass River known as Hatton's Corner, offer to the palæontologist one of the most prolific collecting-grounds in Australia. Amongst the first to investigate these rocks were the Rev. W. B. Clarke [3] and Mr. C. Jenkins,[4] whose work was followed by a survey in 1882 by the Mines Department.[5] Further good work was done by Mr. John Mitchell [6] whilst stationed in the district: but even at this late hour there is a large amount of interesting work awaiting completion.

About ten miles to the south and south-west of the town are found the vast accumulations of Middle Devonian deposits, which are separated from the Upper Silurian rocks by a thick bed of lavas and tuffs which I believe to be the result of volcanic action during the Lower Devonian period.[7]

[1] Broughton, Journ. As. Soc. Bombay, vol. v (1857), p. 639; Lapparent, Traité de Géologie, p. 1611.

[2] Journ. As. Soc. Bombay, vol. v (1857), p. 65.

[3] W. B. Clarke: "Remarks on the Sedimentary Formations of N.S.W.," 4th edition, 1878.

[4] C. Jenkins, "Geology of Yass Plains": Proc. Linn. Soc. N.S.W., vol. iii, pt. 1 (1878), p. 26.

[5] T. W. E. David, "Report on the Fossiliferous Beds, Yass": Ann. Rep. Dept. Mines N.S.W., 1882 (1883), p. 148.

[6] J. Mitchell, "Notes on the Geology of Bowning": Proc. Linn. Soc. N.S.W. (2), vol. i, pt. 4 (1887), p. 1193. "The Geological Sequence of the Bowning Beds, N.S.W.": Report Austral. Assoc. Adv. Science, vol. i, 1888 (1889), p. 291.

[7] A. J. Shearsby, "On the Occurrence of a Bed of Fossiliferous Tuff, etc.": Proc. Linn. Soc. N.S.W., 1905, p. 275.

During a recent collecting tour around Yass, I was fortunate enough to find a large number of specimens of the genus *Rhizophyllum*, amongst which were a new species which I am describing as *R. robustum*, and several specimens of *R. interpunctatum*, De Kon., possessing the opercula *in sitû*. *R. robustum* makes the fourth species of this genus which has been described from the Upper Silurian of the Yass district; and from fragments I have in my collection I am of the opinion that there are several others which await determination.

The following is a description of the new species:—

Genus RHIZOPHYLLUM, Lindström.

Rhizophyllum robustum, sp. nov. (Pl. XXVI, Figs. 1–6.)

Corallum simple, pyramidal, short, widely expanded above, acutely pointed below, lateral angles rounded, section semicircular, plano-convex. Dorsal surface convex; ventral surface flat, both horizontally and vertically. Calice semicircular, moderately deep; dorsal margin sharp and thin, slightly arched above the level of the ventral margin; ventral margin thick, horizontal, with well-marked central fossula. Several thin projecting septa are noticeable on the ventral margin.

A thick corrugated epitheca covers the corallum; that on the ventral side being partly replaced by minute rosettes of Beekite. A portion of the ventral surface is broken away, and shows to a depth of about a quarter of an inch the weathered vesicular internal structure of the corallum. These vesicles have their convex surfaces facing inwards and upwards.

No traces of anchoring stolons are visible on the specimen, the Beekite rosettes near the lateral angles naturally tending to confuse, if not altogether obliterate, these processes. A small portion, probably about a quarter of an inch, of the apex is missing, but otherwise the specimen is well preserved.

The specimen exhibits a most interesting illustration of rejuvenescence by calicinal gemmation; about half of the calice of the corallum being occupied by the upper portion of a young form, which exhibits in a marked degree the same characteristics as the parent form, with the addition of a sub-central depression in the calice. (Pl. XXVI, Fig. 4.)

The measurements of *R. robustum* are as follows:—Parent corallum, length of dorsal surface $1\frac{1}{8}$ inches, length of ventral surface 1 inch.

Note.—Both of these measurements may be increased by an additional quarter of an inch, for, as mentioned previously, portion of the apex is missing.

Parent corallum, greatest diameter of calice $1\frac{1}{8}$ ins., least $\frac{3}{4}$ in. The measurements of the calice of the young form are:—Greatest diameter $\frac{11}{16}$ in., least $\frac{3}{8}$ in., depth $\frac{3}{16}$ in.

R. robustum differs from *R. interpunctatum*, De Kon., by its much greater size and particularly the manner in which the dorsal margin rises above the level of the ventral, causing the angle made between the operculum when closed to be obtuse; while in *R. interpunctatum* the angle is acute on account of the dorsal surface being much shorter than the ventral; and also the ventral surface of *R. robustum*

is flat both horizontally and longitudinally; on the other hand, in *R. interpunctatum* the ventral surface is convex longitudinally.

It is also easily distinguished from *R. australe*, Eth. fil., by its greater size and more deltoid shape and because the ventral surface of *R. australe* is convex in longitudinal section.

It is distinct also from *R. enorme*,[1] Eth. fil., being much smaller in size, more deltoid in shape, and the dorsal surface possessing a higher degree of convexity. The vesicles in *R. robustum* are also much smaller.

It differs from *R. yassense*,[2] Shearsby, in which form the apical angle is obtuse and the upper portion of the ventral surface is convex, being turned in towards the calice.

I have not yet been successful in my endeavours to find an operculum of this species.

Locality and horizon.—Impure limestone on the Wargeila road about half a mile west of Yass Junction Railway Station; Upper Silurian.

Collection.—A. J. Shearsby.

In the accompanying Plate XXVI, illustrating this paper, I have given lateral views of the three other described species found at Yass. The convexity of the ventral surfaces (*v*) of *R. australe* (Fig. 8) and *R. interpunctatum* (Fig. 15) is here well shown in comparison with the flat ventral surface of *R. robustum*. The acute angle between the operculum and ventral surface of *R. interpunctatum* is also clearly illustrated.

Fig. 7 is an outline of a median perpendicular section of *R. yassense*, wherein is depicted the inturned ventral margin of that species.

Operculum, exothecal processes, and calicinal gemmation of *R. interpunctatum*, De Kon. (Figs. 12, 12*a*).

In his description of this species Mr. R. Etheridge, jun.,[3] mentions that the operculum was unknown, and states that the total apparent absence of exothecal structure in *R. interpunctatum* showed a departure towards *Calceola*, in which genus there is no trace of them. I have succeeded in collecting a very large number of this species of *Rhizophyllum*, and several of the specimens have the operculum *in situ*; in addition to these a few detached opercula have rewarded my search.

Figs. 9 and 11 (Plate XXVI) show a corallum with the operculum closed. Figs. 17 and 18 illustrate a fine and almost complete specimen showing the corallum with its operculum widely opened.

The operculum is semicircular and thick, concavo-convex. The upper or outside surface is convex, and is sculptured with concentric bands or lines of growth. The under or inner surface is concave, with a stout median ridge starting from the straight hinge-line, and projecting only about half-way across the surface. Near the hinge where the ridge is stoutest is a small, deep, pit-like, triangular depression, into which the counter septum fits when the operculum

[1] Rec. Geol. Surv. N.S.W., vol. vii (1903), p. 232.
[2] Proc. Linn. Soc. N.S.W., pt. iv (1904), p. 869.
[3] Rec. Aust. Museum, vol. i (1891), p. 203.

is in its place. In several specimens in my collection the insertion of the counter septum in this depression when the operculum is closed is well shown. Besides possessing the stout median ridge, the under surface shows traces of lateral septal ridges. Fig. 12 shows these faintly, but Fig. 12*a* exhibits the granular radiating nature of the ridges more distinctly.

Fig. 18 is a lateral view of a corallum with operculum *in situ* and widely opened. In this figure will be noticed the thickness of the operculum at the hinge-line, and the projecting nature of the median ridge.

Exothecal processes.—Although some scores of these interesting corals have passed through my hands, I have found in only a couple of instances traces of rootlets or anchoring stolons. In both of these the extreme apex of the ventral surface bear two or three very small knobs or protuberances. These being so delicate is no doubt one of the reasons why a complete specimen with rootlets is so rare. Another reason is the apices of the majority of the corals found are missing. One small species of *Rhizophyllum* which I presented to the Australian Museum some time ago exhibits the exothecal processes very clearly, showing as it does at the lateral angles four little knobs, two on each side of the apex. Fig. 16 is a specimen of *R. interpunctatum* from Hatton's Corner, which, besides showing a budding form, has two protuberances on the middle of the ventral surface which may be the remains of rootlets. This is the only specimen I have found which shows them in this position, so I am figuring it for future reference.

Calicinal gemmation.—Many of the specimens which I have collected at Hatton's Corner show very distinct calicinal gemmation. In all of these the young form has completely filled the calice of the parent corallum. Examples of two of these are figured in Pl. XXVI, Figs. 13 to 16. The latter one is of special interest on account of exhibiting, as mentioned above, what appear to be remains of the exothecal processes or anchoring stolons.

Locality and horizon.—Hatton's Corner, Yass; Upper Silurian.

Collection.—A. J. Shearsby.

Further note on the Exothecal Processes of *Rhizophyllum*.

Previous to sending away the foregoing paper I made a minute and lengthy search in places where I knew these corals abounded in order to obtain more complete information as to the occurrence of rootlets on both species; but in spite of over a hundred specimens passing through my hands I was unsuccessful.

It was only about a week after the paper was sent away that I visited a bed of impure coral limestone at Derrengullen Creek, a few hundred yards above the crossing-place of the Yass-Wargeila road, and found amongst numerous other Corals and Brachiopods some fine specimens of *R. robustum*, *R. interpunctatum*, and *R. australe*, Eth. fil. In my description of *R. robustum* I stated that no traces of anchoring stolons or rootlets were visible, the Beekite rosettes tending to destroy any trace of them. One of my specimens from

Derrengullen Creek, however, exhibits the remains of eight stout rootlets (Pl. XXVI, Fig. 19). There were probably more than this number on the complete coral, as the apex is missing, and specimens collected at this locality which have the apex show remains of at least six on this part of the coral.

Of these rootlets some are scattered over the ventral surface, but most of them are situated along the lateral angles. They are hollow and cylindrical, and in some cases branching, and range from mere filaments to as much as a millimetre in thickness. The specimen figured presents another example of calicinal gemmation, the young coral in this case completely filling the calice of the parent form, and exhibiting also an instance of abnormal growth, one side of the coral having grown much faster than the other.

The remaining figures illustrate some fine examples of rootlets on *R. interpunctatum* and *R. australe* from the same locality. In my previous paper I stated that I had only found a couple of specimens showing the exothecal processes, and these consisted of small protuberances at the apex, the remains of probably very small and delicate processes. I figure one (Fig. 16) showing two little knobs about the middle of the ventral surface, which I said might be the remains of rootlets. I am now able to say that my surmise was correct, as I have several examples of this species, which, besides having a liberal allowance of rootlets along the lateral angles, possess extra ones at or near the middle of the ventral surface. Figs. 20–22 are specimens of *R. interpunctatum* which exhibit very clearly the tubular anchoring stolons projecting from the lateral angles. Fig. 21 shows three strong lateral rootlets and the remains of one near the middle of the ventral surface. Fig. 20 is an interesting specimen showing a small parent coral from which has budded a much larger form. This younger coral shows three strong rootlets and one more delicate growing from the lateral angle.

Figs. 23 and 24 are specimens of *R. australe* which exhibit both lateral and median rootlets, Fig. 23 also possessing one on the dorsal surface.

Nearly all my previous specimens of *Rhizophyllum* were obtained in the shale beds at Hatton's Corner, Yass, and in spite of the large number collected there, only two showed faint traces of rootlets. On the other hand, every specimen, with few exceptions, obtained recently during an afternoon's search at this new locality showed remains of well-preserved rootlets in many instances.

It would seem, then, that at Hatton's Corner they had been subjected to violence of some kind before being finally deposited in the shale bed. The violence probably consisted of being rolled to and fro by the action of the waves in the vicinity of the coral reefs which abounded there at that period. The worn and rounded pieces of other corals occurring at Hatton's Corner, in places giving the shales an amygdaloidal appearance, should, I think, help to confirm this opinion.

The occurrence of the delicate rootlets on *Rhizophyllum* in an almost perfect state at Derrengullen Creek, together with some

beautifully preserved small undescribed species of *Tryplasma* and *Cyathophyllum*, which also possess remains of delicate anchoring stolons, points to the existence of quieter waters, probably in the shape of a lagoon or harbour free from the violence of heavy seas.

EXPLANATION OF PLATE XXVI.

FIGS. 1–18: Upper Silurian operculate corals from Hatton's Corner, Yass, N.S.W.:

FIG.

Rhizophyllum robustum, Shearsby.

1. Dorsal view.
2. Ventral view, showing fossula, septa, and vesicular tissue.
3. Lateral view.
4. Calice, showing fossula and calicinal bud.
5. Apical view.
6. Part of ventral surface, showing vesicular tissue. × 2.

Rhizophyllum yassense, Shearsby.

7. Outline of vertical median section.

Rhizophyllum australe, Eth. fil.

8. Lateral view.

Rhizophyllum interpunctatum, De Kon.

9. Lateral view with operculum *in sitû*.
10. Apical view.
11. Dorsal view with operculum *in sitû*.
12. Operculum, inner surface showing median ridge with pit-like depression.
12*a*. Operculum, inner surface showing median ridge and radiating granular lateral ridges.
13. Ventral view of specimen with calicinal bud.
14. Lateral ,, ,,
15. Dorsal ,, ,,
16. Another specimen, ventral view showing calicinal bud, and remains of two exothecal processes (?).
17. Dorsal view of an almost complete specimen with operculum *in sitû* and widely opened, showing median ridge and radiating lateral ridges of operculum, and the counter septum and septa of the ventral wall.
18. Lateral view of same specimen, showing projecting nature of median ridge of the operculum.

d = dorsal surface. *v* = ventral surface.

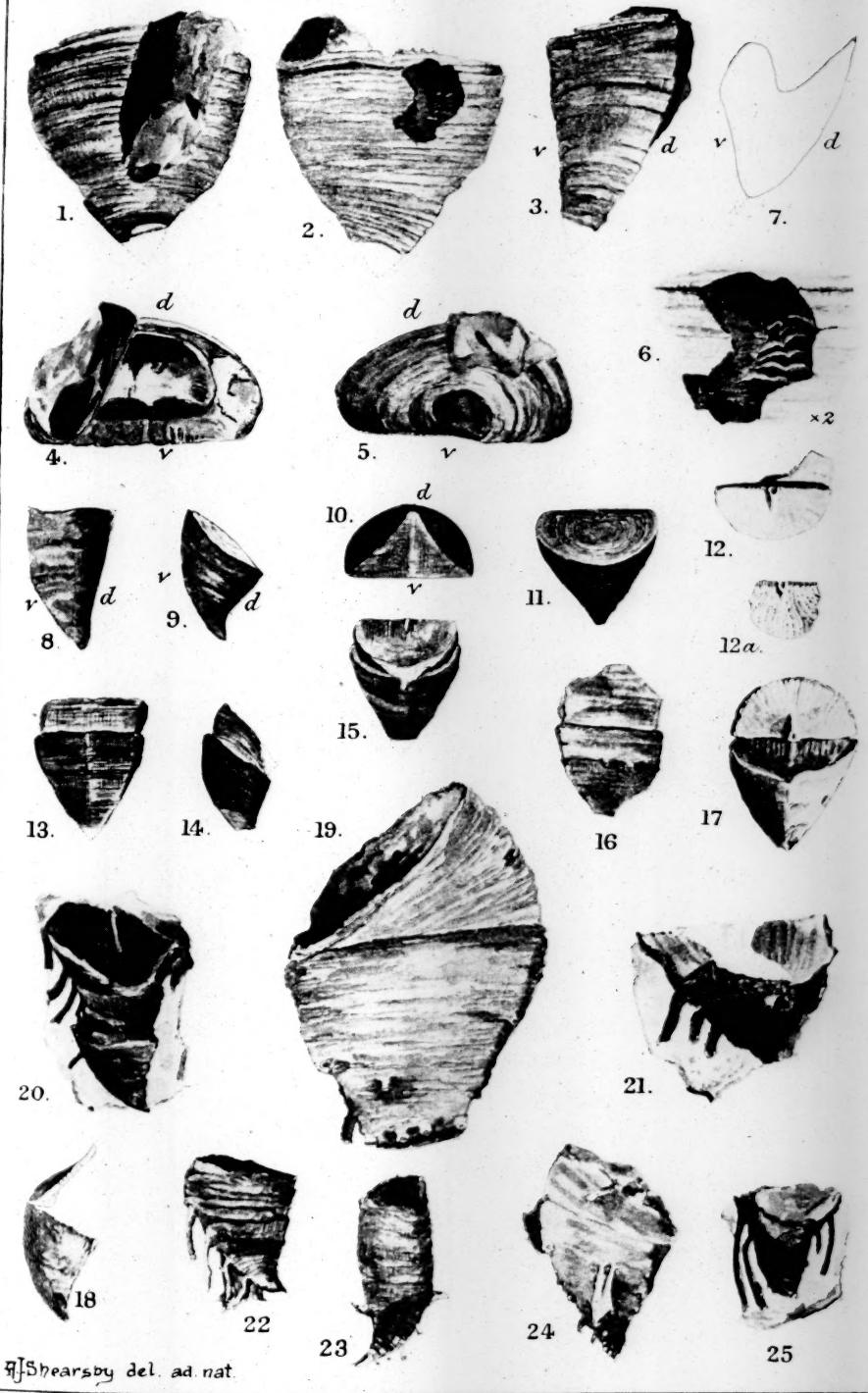
Note.—Fig. 6 is twice natural size; all the other figures are drawn natural size.

FIGS. 19–25: Upper Silurian operculate corals showing exothecal processes, from Derrengullen Creek, Yass, N.S.W.:—

FIG.

19. *Rhizophyllum robustum*, Shearsby. Ventral view showing remains of rootlets, and abnormal growth of calicinal bud.
20. *R. interpunctatum*, De Kon. Dorsal view of budding form, showing one rootlet on the small parent form and four on the bud. The bud also shows a strong counter septum.
21. *R. interpunctatum*. Ventral view showing three strong rootlets at the lateral angle and one near the middle of the ventral surface.
22. *R. interpunctatum*. Lateral view showing rootlets.
23. *R. australe*, Eth. fil. Lateral view with lateral and median rootlets on the ventral surface, and also one on the dorsal surface.
24. *R. australe*. Ventral view with lateral and median processes, and one near the middle of the ventral margin.
25. *R. interpunctatum* (?). Dorsal view of specimen showing four rootlets.

Note.—Figs. 19–25 are slightly magnified.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H.J. Shearsby del. ad. nat.

V. — On Concretionary Nodules with Plant-Remains found in the Old Bed of the Yarra at S. Melbourne; and their Resemblance to the Calcareous Nodules known as 'Coal-Balls.'

By Frederick Chapman, A.L.S., etc.,
Palæontologist to the National Museum, Melbourne.

ALTHOUGH many of the nodular bodies met with in sedimentary rocks which were formerly held to be concretions or simple aggregations of mineral matter have since been found to be due to the work of minute animals or plants, there is yet a more numerous class of true concretions which were undoubtedly formed by chemical reaction in the surrounding water and sediments; the resulting precipitation being often deposited upon nuclei of organic origin, as fish, woody fragments, or shells. Occasionally these nodules were of subsequent formation to the deposit in which they occur. In nodules which include organic remains, the segregation was accelerated by the partial decay of the included organic fragments.

To the latter class belong some interesting examples of spheroidal concretions lately brought under my notice by a keen observer, Mr. F. Spry, of Melbourne. In June, 1900, sewerage excavations were being carried on in S. Melbourne, and at Power Street, near Grant Street, 16 feet below the surface, the concretionary nodules were found which form the subject of this paper. The workmen here struck the bed of one of the old channels of the Yarra estuary. At the time of the formation of this deposit (probably late Pleistocene) the mouth of the Yarra was situated three or more miles to the eastward of the present river mouth, the Saltwater and Yarra Rivers having had separate outlets, instead of, as now, the former joining the latter before entering Hobson's Bay. The earlier course of the Yarra to the sea was thus shortened by about six miles. The estuary was evidently much farther back in late Pleistocene times; but since then the shore-line has been gradually encroaching on Hobson's Bay, owing to the vast quantities of silt carried down by the Yarra and Saltwater Rivers, and also by the drifting of the shore-sand from the eastward, which has been continuously supplied by the disintegration of the Tertiary cliffs from Brighton to Beaumaris. This process of filling up has more than kept pace with the subsidence of the area of the Yarra Delta, as indicated by the level of the old river channel, which is now found at five feet below low-water at S. Melbourne. Since the actual subsidence of this area, however, there has been what is perhaps best termed a negative movement of the shore-line, resulting in a six-foot raised beach, preserved at various parts around Port Phillip Bay.

The details as to the conditions under which the clay nodules were found have been kindly supplied me by Mr. Spry, who considers that the channel, to which reference has been made, was

not the main bed of the river, but a neighbouring backwater, occasionally subjected to tidal influences.

On the sides of the valley sloping to the old river channel at S. Melbourne, several flattened nodules, circular in outline, were found embedded in silt, and in close proximity to the clay bottom. The angle of slope of the sides of the channel at this spot was about 2° (1 in 30). Externally, these nodules have the appearance of flattened balls of clay, mixed throughout with small fragments of dark-brown lignitoid plant-remains and fragments of charred wood.[1] On splitting open some of the nodules, which easily separate, sometimes along the median (equatorial) plane, or in parallel cakes, there is revealed a moderately thick layer, almost entirely composed of matted fragments of woody and foliaceous material, around and amongst which the clay, permeated with a large amount of carbonate

Fig. 1.

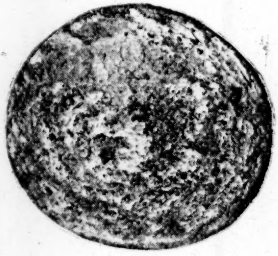


Fig. 2.

Fig. 1.—Cleaved surface of nodule from the old bed of the Yarra at S. Melbourne, showing included fragments of wood. (One-half the diameter of original.)

Fig. 2.—Convex outer surface of the same nodule, showing small fragments of charred wood. (Reduced one-half.)

of lime, seems to have accumulated. The calcareous nature of these nodules is shown by the strong effervescence on treatment with H Cl.

A little of the outer crust of the nodule was taken for examination under the microscope, when it was seen to consist of quartz-grains, fine calcareous and argillaceous particles, brown woody tissue, and valves of the marine diatom *Actinocyclus*.

The residue of the powder from the nodule, after treatment with H Cl, showed it to consist largely of a fine angular quartz sand, the grains of which have a diameter varying generally between ·1 mm.

[1] Mr. Spry has also shown me portions of branches of gum-trees, one of which has been charred by fire. These he found at the bottom of a sewer manhole at the corner of McGowan and Power Streets, at 14 feet from the surface and about 4 to 6 feet below the present low-water mark. Prehistoric bush-fires must have been of frequent occurrence, and may be ascribed to the action of lightning. At the time of writing this note there is a paragraph in the *Argus*, February 14th, 1906, reporting several bush-fires having been started by lightning at Chetwynd and Kadnook in Western Victoria. An interesting feature connected with the above occurrence of drifted wood was a bank of marine shells 7 inches thick, left behind the logs by the retreating tide. See also the reference to charred wood in coal-seam nodules by A. C. Seward ("Fossil Plants," vol. i, p. 88).

and ·018 mm. Some tourmaline and zircon crystals were also present, probably derived from the acid igneous dykes of the neighbourhood, and also remains of diatoms.

These nodules differ in appearance from the irregular concretions found in the estuarine swamps near Melbourne, in having an almost circular outline, as if artificially rounded (so much so that the workmen considered them to be 'faked'). From the occurrence of the nodules on the sides of the old river channel, and seated in depressions, we may reasonably assume that they received their form in 'kettles' or 'potholes' in the clay bottom of the river bed, within reach of tidal influence.

It was whilst examining the calcareous nodules from the old Yarra channel that the writer was impressed with the close resemblance they bore to the 'coal-balls' of the Coal-measures in England. The coal-seams of the Yorkshire and Lancashire Coalfields contain calcareous nodules which include portions of Coal-measure plants in a very perfect state of preservation. These nodules vary in size, but are usually a few inches in diameter, and more or less flattened. They are spoken of as 'coal-balls,' although that term has also been applied to the rounded nodules of pure coal having a concentric structure, which are met with in the coal-seams of England, France, New South Wales, and elsewhere. The former class of 'coal-balls,' however, are highly calcareous, being composed of about 70 per cent. of carbonate of lime and magnesia, and 30 per cent. of oxide of iron, sulphide of iron, etc.[1] A great interest attaches to these calcareous 'coal-balls' on account of their having furnished the palæobotanists Binney, Williamson, Scott, and others with some of the best preserved Coal-measure plants upon which they based their valuable observations.

The general form of the nodules from the Coal-measures is a flattened sphere; and in this respect, amongst others, they resemble the nodules from the Yarra. That the shape of the 'coal-balls' is due to segregation of carbonate of lime from the overlying beds deposited radially and concentrically is open to serious objection, since the nodules include pieces of *Lepidodendron* stems, Calamitean roots, and other woody remains, which, by their rod-like shape in the conglomerated mass of sticks and stems, would tend to interfere with an incipient crystallization or segregation acting from a central point. This idea of segregation *in situ* is, however, the generally accepted one, and was clearly stated by Professor T. Rupert Jones in his Presidential Address to Section C, British Association Meeting at Cardiff in 1891,[2] in the following words:—"The 'coal-balls' of Oldham, in Lancashire, and the bullions at South Owram, in Yorkshire, are calcareous-carbonaceous nodules in coal, having been formed by the infiltration of water carrying carbonate of lime from the shells in an overlying shale

[1] See Cash & Hick: Proc. Yorkshire Geol. and Polytech. Soc., vol. vii (1878–1881), p. 73. Also Seward: "Fossil Plants," vol. i (1898), p. 85.

[2] Report, 1892, p. 13. See also D. H. Scott: "Studies in Fossil Botany," 1900, p. 11.

down into the bed of woody fragments and other bits of dead plants. The carbonate of lime there segregated from the mass to certain centres, and preserved, in round nodules, the vegetable structures, before they were quite decomposed, more or less distinct, as they had fallen on the forest floor."

Considering the perfect preservation of most of the stems, leaves, and other plant-remains found in the nodules from the Coal-measures, it seems evident to me that they were sealed up at an early stage in the formation of the deposit. The calcareous matter was most likely supplied by small shells, such as Goniatites,[1] caught up in the tangled mass of vegetable remains, which, on being dissolved by the organic acids generated from the decaying bodies of small organisms likely to be present, quickly redeposited around the woody fragments, and, as in the case of the nodules from the Yarra, the balls finally received their rounded contour from the swirling action of eddies and currents.

On breaking open one of the nodules from the Yarra, the resemblance to a fractured 'coal-ball' is very striking, the plane of fracture often showing a matted mass of twigs and woody fragments, together with seeds and some of the more durable leaves. In the light of the data used in the above comparison it is therefore certainly worth a further enquiry into the tenability of the theory of the 'coal-balls' of England being formed *in sitû*; and especially in view of the evidence already known, which goes to prove an allochthonous origin for much of the coal-deposits of various ages in different parts of the world.

VI.—A New Palæoniscid Fish from the Base of the Pendleside Series near Holywell, Flint.

By Dr. R. H. Traquair, F.R.S., F.G.S.

THE remains of a Palæoniscid fish from the Lower Carboniferous rocks of Flintshire, submitted to me by Mr. J. T. Stobbs, are unfortunately not sufficiently perfect to afford material for a complete diagnosis. The specimen shows the impressions of the outer surface of both mandibular rami and of the left maxilla, and beyond this we have only a mass of dislocated scales—the general form of the fish, the position of the fins, and the condition of the fin-rays being entirely lost.

The mandible is three-quarters of an inch in length, slender and tapering, the external sculpture, according to the impression left, consisting of fine close ridges, which, in feather fashion, diverge upwards and forwards and downwards and forwards from a line running longitudinally along the middle of the surface, thus forming

[1] Whilst writing these notes I have received a valuable and suggestive paper by M. H. Douvillé, "Les 'Coal-balls' du Yorkshire," from the Bull. Soc. Géol. France, sér. IV, vol. V, pp. 154–156, pl. VI, in which that author records the association of large numbers of Goniatites (*Gastrioceras*), *Nautilus*, *Orthoceras*, *Aviculopecten*, and other marine shells, with the coal-balls and their vegetable contents.

a series of backwardly directed acute angles. The maxilla is of the usual palæoniscid form, the suborbital process being long and slender, and the expanded postorbital portion ornamented, according to the impression, with fine ridges, which mostly run parallel with the posterior and superior borders.

Among the scales may be distinguished some which are nearly equilateral and only slightly oblique—these belonged to the flank; others, longer than high, were ventral in position; while others again, smaller in size and more oblique in contour, appertained to the tail. The flank scales are about $\frac{1}{10}$ inch in height, and have nearly the same breadth; the overlapped area is scarcely perceptible; the free surface is marked with fine striæ, which run mostly parallel with the upper and lower margins, a very few of the lowest ones turning up in front so as to run parallel with the anterior margin, while again a number of deeper indentations divide the posterior margin into six to eight strong and sharp denticulations. The ventral scales, being lower in contour, have fewer denticulations on

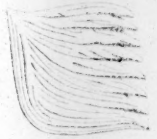
Fig. 1.  $\frac{10}{1}$

Fig. 2. $\frac{10}{1}$

Fig. 1.—Flank scale of *Elonichthys denticulatus*, Traquair, sp. nov.
Fig. 2.—Ventral scale of same species.
Lower Carboniferous Rocks (Pendleside Series): near Holywell, Flintshire.
Both figures magnified ten diameters.

the hinder border, these numbering from three to five. As to the caudal scales, though it is evident that they remained highly ornate up to the extremity, it is not clear how far posteriorly the denticulated character persisted.

The configuration of the mandible and maxilla clearly proves that the place of the present fish is in the family Palæoniscidæ, but owing to the complete absence of fins or fin-rays the evidence as to the genus is not conclusive. According to the form and sculpture of the scales, and the configuration of the jaws, the fish might appertain either to *Rhadinichthys* or to *Elonichthys*. Perhaps the scales have the greatest resemblance in sculpture to those of *Elonichthys Egertoni* (Egert.), but the denticulations of the posterior margin are proportionally coarser. Any way the association, on these scales, of fine striæ with comparatively coarse denticulations of the hinder margin, is a feature which leads me to believe that the species is new to science. I therefore propose to name it *Elonichthys denticulatus*.

NOTICES OF MEMOIRS.

I.—Memoirs of the Geological Survey.

THE following Memoirs, in addition to those already noticed, have been issued during the present year :—

(1) The Geology of the Scilly Isles. By George Barrow, F.G.S., with petrological contributions by J. S. Flett, M.A., D.Sc. 8vo; pp. 37, with 7 plates. (Price 1*s.*)

In this memoir a particular description is given of the Granite and associated rocks which form the Isles of Scilly.

Attention is also directed to the various superficial deposits of Raised Beach and Blown Sand, and to the occurrence of Glacial Drift. The evidence of recent movements in the area is discussed, and remarks are made on the industries and on the water supply.

The memoir is accompanied by a colour-printed geological map (Sheets 357 and 360), and it contains six plates depicting the scenery. The map is the first issued of the area on the one-inch scale; the price is 1*s.* 6*d.*

(2) The Geology of the Country near Sidmouth and Lyme Regis. By H. B. Woodward, F.R.S., W. A. E. Ussher, F.G.S., with contributions by A. J. Jukes-Browne, B.A., F.G.S. 8vo; pp. 96, with a plate and 39 text-figures. (Price 1*s.*)

In this memoir there is a description of the strata exhibited in the fine cliff-sections from the New Red Sandstone and Marl of Sidmouth to the Rhætic Beds and Lias of Axmouth and Lyme Regis, together with an account of the overlying Gault, Upper Greensand, and Chalk. Inland the country around Honiton and Axminster is described. Figures are given of some of the common Lias fossils found in this richly fossiliferous region. The plateau and valley deposits, the famous Landslip of Bindon, and the economic products of the area receive due attention.

The memoir is accompanied by a colour-printed map (Sheets 326 and 340), price 1*s.* 6*d.*

(3) The Geology of the Country around Macclesfield, Congleton, Crewe, and Middlewich. By T. I. Pocock, M.A., with contributions by G. Barrow, W. Gibson, B.Sc., C. B. Wedd, B.A., and J. A. Howe, B.Sc., and notes on fossils by E. T. Newton, F.R.S. 8vo; pp. 138, with 2 plates and 8 text-figures. (Price 2*s.* 6*d.*)

This memoir is descriptive of parts of Cheshire and Staffordshire, including the northern end of the Potteries Coalfield, and portions of the coalfield and salt-bearing districts of Cheshire. We note that the term Pendleside Series is adopted for the strata between the Carboniferous Limestone and Millstone Grit.

The area, consisting mainly of Carboniferous and New Red rocks,

is extensively covered with drift; and a detailed account is given of these superficial deposits, together with notes on the shells from the high-level gravels of Macclesfield.

The memoir is accompanied by a colour-printed map (Sheet 110), price 1*s.* 6*d.*

(4) The Water Supply of Suffolk from Underground Sources, with Records of Sinkings and Borings. By W. Whitaker, B.A., F.R.S., with contributions by H. F. Parsons, M.D., H. R. Mill, D.Sc., and J. C. Thresh, D.Sc. 8vo; pp. 177, with map. (1906. Price 3*s.* 6*d.*)

In this memoir Mr. Whitaker gives a general outline of the water-bearing strata, and summarizes some points of special geological interest in connection with the numerous records of borings. Notable among these records is that of a boring at Glemsford, which proved a thickness of 470 feet of Glacial Drift, much to the perplexity of the well-borer, and of special interest to the geologist as being the greatest recorded thickness of Glacial Drift in Britain. Full details are given of the Stutton boring, which was carried down to a depth of 1,525 feet, reaching Palæozoic rocks beneath the Gault. The records deal mostly with wells or borings for water, and analyses of water are appended. Dr. Mill contributes a map and statistics relating to the rainfall.

(5) Water Supply of the East Riding of Yorkshire, from Underground Sources, with Records of Sinkings and Borings. By C. Fox-Strangways, F.G.S., with contributions by H. R. Mill, D.Sc. 8vo; pp. 181, with map and 3 illustrations. (Price 3*s.*)

This memoir contains an outline of the geology of the East Riding and of portions of the Vales of York and Pickering, with especial reference to the water-bearing strata. It contains records of all known sinkings and borings in the area, together with analyses of waters, and a bibliography. There is also a section on the rainfall with a colour-printed map, by Dr. Mill.

(6) Soils and Sub-Soils from a Sanitary Point of View. With especial reference to London and its Neighbourhood. By Horace B. Woodward, F.R.S. 8vo; pp. 58, with 18 illustrations and colour-printed map. Second edition. (Price 1*s.* 6*d.*)

The object of this work has been to supply information regarding sites for houses and other questions involving the applications of geology to sanitary science; and it includes notes on sewage-farms and cemeteries. In this second edition the chapter treating of water-supply and drainage has been enlarged, with especial reference to the residential areas within easy reach of the Metropolis. A new colour-printed map on the scale of an inch to four miles is given in the memoir. It includes Guildford, Sevenoaks, Chelmsford, and Rickmansworth.

II.—The Tenth Meeting of the International Geological Congress, held in the City of México, September, 1906. [Being the Abstract of a Report prepared and communicated by Bernard Hobson, M.Sc. Vict., F.G.S., a Memb. Int. Geol. Congress.]

THE tenth triennial meeting of the International Geological Congress was held this year in the city of México. The Mexican Government acted with the greatest liberality towards the members of the Congress, while the inhabitants of the country did their utmost to make their visitors feel that Mexico was not behind any other country in its hospitality to strangers. Excursions to places of geological interest were set on foot, and an excellent guidebook, containing the most recent information relating to the districts to be visited, was provided. The excursions included visits to Vera Cruz, the volcanoes of Jorullo and Colima, Mitla Monterrey, San Luis Potosi, the isthmus of Tehuantepec, etc.

The Congress was opened in the School of Mines on September 6th by the President of the Republic, General Porfirio Diaz.

The first paper presented was a memoir entitled "Die Trochilisken," by M. Karpinski. These are fossils of problematic origin, limited to the Devonian. Mr. Heilprin read a paper on "The concurrence and interrelation of Volcanic and Seismic Phenomena," in which he advanced the opinion that earthquakes considered to be of tectonic origin may really be due to volcanic agency sometimes remote from the seat of the disturbances. In the discussion which followed Professor A. C. Lawson, of Berkeley, California, dissented from this view.

Dr. Renz's paper, "Ueber das ältere Mesozoicum Griechenlands," showed the importance of the marine Trias of Alpine facies in Greece, and pointed to the identity with the Trias of some marmorized limestones hitherto regarded as Cretaceous.

On September 7th a party of the members, under the guidance of the Secretary, Mr. E. Ordóñez, inspected the olivine-basalt lava stream at Coyoacan, six miles S.S.W. of México. The lava issued from the volcano of Xitli, and it covers 60 square kilometres, being 30 kilometres long and 5 kilometres in maximum width (E. Ordóñez in Bol. del Inst. Geol. de México, No. 2, 1895).

At the meeting on the 8th September Professor F. D. Adams, of Montreal, described the Geological Map of North America prepared at the expense of the Geological Survey of the United States, the material having been supplied by the Geological Surveys of Mexico, the United States, and Canada. The nomenclature adopted is that of the American Survey. In the discussion following the reading of this paper the nomenclature was in some points called in question by the Canadian geologists present.

Professor Edgeworth David, of Sydney, then read a paper on "Changes of Geological Climates," with special reference to Cambrian and Permo-Carboniferous glaciation in Australia and India.

The climatic evolution of the earth from the Palæozoic to the

present epoch was the subject of a paper by Professor Frech, of Breslau, who maintained that this evolution has always progressed in correlation with changes in the proportion of carbon dioxide and aqueous vapour in the atmosphere. A discussion upon this paper took place at the afternoon session. Professor Stefanescu, of Bucharest, described a new species of *Dinotherium*, viz. *D. gigantissimum* (Stef.), which he discovered in 1888 at Manzati, in Roumania. This is the first complete skeleton found up to the present time.

An excursion, in which 190 members of the Congress took part, was made on the following day (9th September), under the auspices of the Mexican Geological Society, to Cuernavaca, 74 miles south of the city of México. Fine views were obtained *en route*, including a distant one of the snow-capped Popocatapetl.

On the 10th September the discussion on the condition of climates in geological time was renewed and concluded, and on the 11th a large number of members joined in an excursion to San Juan Teotihuacan, the sacred city of the ancient Toltecs, situated 29 miles north-east of México. Here they inspected two pyramids dedicated to the Sun and Moon, the former 216 and the latter 151 feet in height.

The meeting of the 12th September was occupied by the reading and discussion of a paper by Mr. Joh. Königsberger, entitled "Ueber den Verlauf der Geoisothermen in Bergen und seine Beeinflussung durch Schichtstellung, Wasserläufe, und chemische Processe." It was followed by papers on the latest eruption of Vesuvius by Mr. Sabatini and Dr. Tempest Anderson, and in the evening of that day the members of the Congress were entertained at a banquet at the palace of His Excellency the President.

An excursion to the silver-mines of Pachuca was carried out on the 13th September.

On the 14th September Professor A. C. Lawson presented his paper on the earthquake of San Francisco, which provoked an interesting discussion. Professor Frech pointed out the analogy between the Californian earthquakes and those preceding them in Europe, notably that of Dobratsch, in Carinthia. He drew attention to the fact that the earthquake of Dobratsch followed, equally with that of California, a certain tectonic line which was conspicuous both in the mountain formation and in the course of the valleys. He also pointed out the remarkable fact that in neither country was there any true volcanic action.

A paper, which must have proved interesting to the glacialists, was read by Professor A. P. Coleman, of Toronto, on "Interglacial Periods in Canada."

"A Meteorite Crater of Arizona" was the subject of a communication by Professor H. L. Fairchild, of Philadelphia, and in the afternoon of the same day Professor Edgeworth David read his paper on the occurrence of diamond in matrix at Oakey Creek, Inverel, New South Wales.

Mr. H. F. Reid, of Baltimore, then communicated an extract from the report of the International Committee on glaciers, and the

General Secretary that of the Committee on Co-operation in Geological Investigations.

Mr. Sjögren, of Stockholm, gave an invitation for the eleventh meeting of the Congress to take place at Stockholm, at the instance of Messrs. Törnebohm and J. G. Anderson, President and Secretary of the Swedish Committee. This invitation was gladly accepted, and, after some congratulatory remarks by the President and others, the Congress was declared closed.

REVIEWS.

I.—Geology of Armenia.

A Treatise on the Geology of Armenia. By Felix Oswald, B.A., D.Sc. Thesis accepted by the University of London for the Degree of Doctor of Science. In two parts: I. Geological results of a journey by the author through Turkish Armenia. II. The Geological Record of Armenia. 8vo; pp. ix, 516, maps, plates, and sections. London (printed at Dulwich by the author, and published by the author at Iona, Beeston, Notts), October, 1906. Price one guinea, net, 100 copies only printed.

THIS is a remarkable book in more ways than one. It is no small feat to write a book on the geology of Armenia, which embodies all that has gone before, plus a vast amount of original research: but when the traveller and author deliberately sits down to set up his own manuscript, draw, print, and colour his own maps and sections, and turn out the five hundred and odd pages of a complete book, with the sole exception of the binding, it demands more than passing attention.

Mr. (now Dr.) Oswald accompanied Mr. H. F. B. Lynch on his second journey through Turkish Armenia in 1898. Mr. Lynch's volumes appeared in 1901, and the delay in publication of Dr. Oswald's book is due to the fact that he prepared many of the maps, plans, and other illustrations for his friend's work, before finding the necessary leisure to prepare his own. He acknowledges help received from Dr. T. G. Bonney, Mr. R. B. Newton, Mr. G. C. Crick, Col. F. R. Maunsell, and Col. G. S. Elliot, and these names, together with the Bibliography (pp. 487–500) and the general treatise on Armenian geology, show that the work has been sweeping and comprehensive in character.

The country dealt with lies between the Caspian and Black Seas, including to the south the Euphrates and Tigris rivers and the lakes Van and Urmi. The author's route, told in successive chapters each geologically treated, was as follows:—Constantinople to Trebizond, Trebizond to the Vavuk Pass, to Erzerum, to Khinis, to Tutakh, to Akhlat, thence to the Tauric Heights, the Nimrud Volcano, Akhlat to Sipan, to Khamur, to the Bingöl Cliffs, Bingöl Volcano, Erzerum to Trebizond. The observations made during this journey occupy thirteen chapters, and the remaining ten chapters treat of the general

geology of Armenia system by system. The volume closes with a note by Dr. Bonney on rocks collected by Mr. Lynch in 1893, a bibliography, and voluminous index. On the value of the two last items we need not enlarge.

In an introductory chapter Dr. Oswald discusses the orography of the Asiatic continent, and calls attention to the Armenian plateau as the natural bridge between Central Asia and Southern Europe, illustrating his remarks with maps. He regards the chief eras of mountain folding in Armenia as belonging to the Lower Permian, ante-Tithonian, and post-Oligocene periods, and at each time the pressure came from the south (the Arabian tableland), while the northern limit to all this folding was formed by the great granitic 'horst' of the Meschic Mountains. The lines of fracture are carefully explained in the text and on the maps, and the author points out that the position of the numerous volcanos of Armenia is by no means fortuitous, but on the contrary they have invariably arisen along these lines, while those volcanos which occur at points of intersection are proportionately larger. Gently folded Miocene limestones are characteristic of the plateau, but never occur in the border ranges; on the other hand, while metamorphic schists are characteristic of the Taurus, they occur only quite exceptionally in the plateau region. The depressions along the lines of fracture became filled by lake-deposits during Pliocene and Pleistocene times, and lavas and tuffs of contemporary volcanos became interbedded with the later deposits, and assisted in levelling the pre-existing inequalities of the ground.

Special attention has been paid to the petrology, and numerous long footnotes describe in detail the rocks met with by the author in his journey. The book is remarkably free from misprints, is full of topographical detail, and is the first attempt which has been made to write a systematic geological history of an interesting portion of the world. One can only regret that Dr. Oswald has (owing to the extreme difficulties under which his volume has been produced) printed but one hundred copies, for it is quite evident that his book must remain for a considerable period the chief work of reference on the geology of Armenia. C. D. S.

II.—Geological Map of the Colony of the Cape of Good Hope. Sheet I. Published by the Geological Commission, 1906. Geology: by A. W. Rogers, E. H. L. Schwarz, and A. L. Du Toit.

THE Geological Commission of Cape Colony has now been at work for over ten years. During this period it has issued valuable Annual Reports with small scale maps illustrating the areas surveyed. The present map, then, can be regarded as the outcome of years of arduous field-work, undertaken by the Director, Mr. A. W. Rogers, with the assistance of Messrs. E. H. L. Schwarz and A. L. Du Toit. The manner in which this survey has always been carried on has led us to expect that the final map would be

a standard. There can be no doubt that Sheet I represents the results of long-continued and brilliant geological investigation.

The present map, which is on the scale of about 3·7 miles to the inch, includes Cape Town and its well-known suburbs; the towns of Robertson, Ladygrey, Caledon; and the coastline from a little north of Cape Town to within ten miles of Cape Agulhas. The farms are named and their boundaries represented. Heights are unfortunately few and far between—a serious omission on a map on which the mountain ranges are only indicated by a name written along their general trend.

The geological formations represented by colour extend from the Malmesbury Series to the Uitenhage Series, the superficial deposits being uncoloured. The intrusive rocks are shown by two colours, one for the dolerites and diabases and another for the quartz porphyries and granites intrusive into the Malmesbury Series. The colours throughout are clear and distinctive, and bring out the structure at a glance.

The alterations from maps published previous to the work of the Commission include the representation of a series of grits, arkose, and conglomerates—French Hoek Beds—probably newer than the Malmesbury Series and certainly older than the Table Mountain Sandstone. The Witteberg Series are separated and coloured distinctively from the Table Mountain Sandstone. This clearly brings out the structure of the folded regions. A considerable area of the Dwyka Series and Ecca Series is shown on the downthrow side of the Worcester-Robertson Fault. The Enon Conglomerate is definitely correlated with the Uitenhage Series.

It is nowadays demanded of a Geological Survey that it should be of economic value. In questions of water supply from underground sources, irrigation works, and agriculture, the present map is patently of service. It is not, however, so generally known that the systematic geological survey of Cape Colony has yielded results of fundamental importance in determining the geological succession of the neighbouring, and, from a mining point of view, more favoured colonies. In this respect it is not altogether gratifying to learn that the work of the Cape Geological Surveyors is more keenly watched and more highly appreciated abroad than in this country.

While engineers will naturally make use of these maps, no geologist, claiming to be cosmopolitan in his aims, can neglect the structure so clearly illustrated in the geology of Cape Colony.

The map is unpriced.

III.—A New Geological Map of North America.

At the meeting of the Tenth International Geological Congress in the city of Mexico, on September 6th, copies of a new geological map of North America were distributed to the members present. It is accompanied by a descriptive text written by Mr. J. G. Aguilera, "Aperçu sur la géologie du Mexique pour servir à l'explication de la Carte géologique de l'Amérique du

Nord." The map itself is entitled "Congrès Géologique International. Dixième Session, 1906. José G. Aguilera, Président. Ezequiel Ordóñez, Secrétaire général. Carte Géologique de l'Amérique du Nord. Dressée d'après les sources officielles des Etats Unis, du Canada, de la République du Mexique, de la Commission du Chemin de Fer Intercontinental, etc. Henry Gannett, Géographe. Bailey Willis, Géologue. Echelle 1 : 5,000,000, 1906." (Scale = 78·9 miles to one inch.)

The map embraces the whole of North America, and includes Alaska, the Parry Islands, Greenland, Iceland, Canada, United States, Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, the West Indies, and part of Colombia and Venezuela. By an extraordinary oversight the island of Cozumel off Yucatan is omitted. Twenty-five distinctive colours are employed, the subdivisions being Effusive Rocks, Intrusive Rocks, Pre-Cambrian, Eo-Algonkian, Neo-Algonkian, Metamorphic Palæozoic, Palæozoic, Cambro-Ordovician, Ordovician, Silurian, Devonian, Carboniferous, Mississippian, Pennsylvanian, Permian, Trias, Jurassic and Triassic, Lower Cretaceous, Upper Cretaceous, Laramie and allied formations, Eocene, Neocene, Miocene, Pliocene and Quaternary, Quaternary. The Quaternary is only shown in localities where it completely covers the subjacent formations.

As one would naturally expect, there are blank areas in parts of Alaska, North-West Canada, Idaho, Nevada, Utah, Arizona, California, New Mexico, Texas, Lower California, and the States of Guerrero, Oaxaca, and Vera Cruz, and parts of Honduras, Costa Rica, Nicaragua, and Panama.

The map is beautifully printed, and consists of four sheets, each $28\frac{3}{4}$ inches (73 cm.) by $37\frac{1}{4}$ inches ($94\frac{1}{2}$ cm.), measured over the engraved work.

The comparative scantiness of place-names is a slight drawback in a very handsome and useful map.

The colour index is in French and Spanish.

This map is the result of a resolution proposed by the late Professor I. C. Russell at the Ottawa meeting of the Geological Society of America, to the effect that it was desirable to prepare a geological map of North America for the International Congress at the city of Mexico. A committee was appointed, consisting of Professor I. C. Russell (chairman), Professor F. D. Adams, Sr. José G. Aguilera, Mr. C. W. Hayes, and Mr. Bailey Willis. Mr. Bailey Willis was officially charged with the work of compiling the map.

The accompanying pamphlet by Mr. Aguilera consists of a title-page and 22 pages of text (size of page 11 inches by $7\frac{3}{4}$ inches), and gives a useful sketch of the geology of Mexico. Fuller details will be found in the "Sinopsis de geología Mexicana," Bulletins 4, 5, and 6 of the Inst. Geol. de México, 1897, of which an abstract appeared in *Science Progress* (New Series), vol. 1, 1897, pp. 609–615. A pamphlet by Mr. Bailey Willis entitled "Carte géologique de l'Amérique du Nord" (and in English, "Geological Map of North

America") also accompanies the map, and consists of a title-page and 12 pages (11 inches by 7¾ inches). It consists chiefly of historical introduction and notes on classification and colouring of the Geologic Series. BERNARD HOBSON.

IV.—GEOLOGICAL SURVEY OF CANADA. A. P. LOW, B.Sc., Deputy Head and Director. PALÆOZOIC FOSSILS. Vol. iii, part 4 (and last). By J. F. WHITEAVES, LL.D., F.G.S., F.R.S.C. pp. 243–352, with pls. xxiii–xlii. (Ottawa, September, 1906.)

THIS memoir contains four distinct papers, numbered in continuation of those contained in the previous parts, viz.: (5) The fossils of the Silurian (Upper Silurian) rocks of Keewatin, Manitoba, the north-eastern shore of Lake Winnepegosis, and the lower Saskatchewan River. (6) The Canadian species of *Plectoceras* and *Barrandeoceras*. (7) Illustrations of seven species of fossils from the Cambrian, Cambro-Silurian, and Devonian rocks of Canada. (8) Revised list of the fossils of the Guelph Formation of Ontario.

5. The Keewatin fossils comprise two series. The first, collected at Rainy Island and 17 to 30 miles below it, consist of few and fragmentary specimens which were originally referred provisionally to the Devonian. The second series, obtained in 1901 from similar rocks on the Ekwan River and other localities in the province, furnished unmistakable evidence of the true age of the rocks, which proved to be Silurian. The following classes are represented in these collections, which contain twenty-three species from the Ekwan River, described in Ann. Rep., vol. xiv, pt. F, 1904, but illustrated in this memoir for the first time:—Spongiæ, Anthozoa, Hydrozoa, Echinodermata, Polyzoa, Brachiopoda, Mollusca, Crustacea (Ostracoda, Trilobita).

The fossils from Manitoba (Stonewall and Davis Point, Lake Manitoba) comprise a few species of Corals, Brachiopods, and Molluscs; those from Davis Point, Lake Manitoba, three species of Corals and a doubtful Stromatoporoid. From the north-east shore of Lake Winnepegosis, and also from the Lower Saskatchewan, species representative of the Anthozoa, Brachiopoda, Mollusca, and Crustacea were obtained.

6. This section contains critical comments upon the following species of *Plectoceras* and *Barrandeoceras*; the original descriptions of both genera and species being given in full:—*Plectoceras Jason*, Billings (sp.); *P. Halli*, Foord (sp.); *P.* (?) *undatum*, Conrad (sp.); *Barrandeoceras natator*, Billings (sp.); *B. Minganense*, Hyatt; *B. subcostulatum*, Whiteaves; *B. vagrans*, Billings (sp.).

7. These species have been described, at various times, in the *Canadian Record of Science* or in the *Ottawa Naturalist*, but none of them have been either described or figured in the publications of the Geological Survey, and four have not previously been figured anywhere. They are as follows:—*Anomalocaris Canadensis*, Whiteaves, from the Cambrian rocks of British Columbia, a species

of doubtful affinities: *Cyrtoceras Quebecensis*, Whiteaves, from the Levis Formation of Quebec; *Steganoblastus Ottawaensis*, Whiteaves, *Matheria brevis*, Whiteaves, and *Spyroceras Beauportense*, Whiteaves, from the Trenton Limestone of Quebec and Ontario.

8. This list chiefly concerns the nomenclature of the species, which has been brought up to date, but it also includes changes made in the identification of the species based on the reconsideration of their supposed affinities in the light of new or more ample material. Dr. Whiteaves adds important observations on some of the species from his own rich stores of knowledge, and Dr. E. O. Ulrich also contributes valuable criticisms on some of the species that were submitted to him. The groups dealt with belong to the Anthozoa, Hydromedusæ, Brachiopoda, and Mollusca.

An appendix containing errata to parts 1–3 of the volume, and an index to the generic and specific names in the whole volume, complete the work. A. H. F.

V.—Geological Survey: Western Australia. Bulletin No. 22: The Auriferous Deposits and Mines of Menzies, North Coolgardie Goldfield. By Harry P. Woodward, Assistant Government Geologist. 8vo; pp. 1–92, with two maps and six plates of sections. (Perth, W.A., 1906.)

THIS excellent report upon the important gold-mining district of Menzies forms part of a series treating of different mining centres of the State.

The geological work is based upon Mr. W. D. Campbell's topographical map prepared in the year 1899. The area embraced by the report covers about 50 square miles, and includes the productive part of the district so far as it has been investigated.

In its salient geological features Menzies consists of a complex of basic rocks with intrusive acidic dykes which were most probably derived from the large granitic mass forming the higher ground in the vicinity of Springfield, near the eastern border of the map. A covering of superficial deposits has rendered geological mapping difficult, but the different rock masses have been delineated as accurately as the scale of the field plans would admit of.

The basic crystalline rocks are of much importance owing to their intimate connection with the auriferous quartz reefs of the district. They consist mostly of amphibolite and diorite, with their derivatives—serpentine, chlorite, and hornblende schists.

The acidic rocks occupy only a relatively limited area of the surface in the vicinity of Springfield, though their presence to the north and west has been proved in wells and quarries. They consist of gneiss, mica schist, and sericite schist, and, as is the case with the basic rocks, the schistose character seems to be lost at a variable depth below the surface. A portion of the field is traversed by numerous acidic dykes, generally represented by sericite schists and allied rocks, with transitions to porphyritic granite.

The quartz reefs, which are confined to the greenstones, are of

various types and of somewhat different characters. Most of the gold from Menzies has been obtained from segregation reefs, which have an irregularly lenticular form; they constitute a series of small but rich parallel veins. There are also one or two fissure veins, which though poor in their gold contents are promising by reason of their extent and their probable continuity in depth.

Mr. Woodward has made an examination of all the mines to which he could obtain access, and has supplied full descriptions of each in relation to their economic value and to their geological characteristics.

Statistics show that a little more than 400,000 ounces of gold were obtained up to the close of 1905, and it is observed that a considerable quantity is still got out by working miners aided by a State battery.

This report by Mr. H. P. Woodward deserves commendation for the very careful manner in which it has been prepared, and the Chief Geologist is to be congratulated upon having acquired the services of so able a coadjutor in the work of the Survey.

A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

The opening meeting of the Session was held on November 7th, 1906. Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the chair.

The following communications were read:—

1. "The Upper Carboniferous Rocks of West Devon and North Cornwall." By E. A. Newell Arber, M.A., F.L.S., F.G.S.

After a reference to the previous work in the area, the author gives a description of the coast-sections, which display a highly disturbed sequence of Upper Carboniferous rocks. Special attention is paid to two lithological types — the carbonaceous rocks, which contain inconstant and impersistent beds of the impure, smutty coal, known locally as 'culm'; these beds have yielded plant-remains; and the calcareous rocks, partly of marine and partly of fresh-water origin, consisting of well-marked, impersistent bands of impure limestone, and conglomeratic beds of calcareous nodules embedded in shales. One of the limestone bands, the Mouthmill Limestone, is marine, and contains an abundant fauna; while in others the only fossils are *Calamites Suckowi* and *Alethopteris lonchitica*. The calcareous nodules, which are not ferruginous, occur in thin shale-beds, 2 to 3 feet thick; they commonly contain a marine fauna, with Goniatites, Lamellibranchs, and fish-remains. The fossil flora and the horizon of the beds are next discussed, lists of plants being given from various localities; and the conclusion is reached that the rocks belong to the Middle Coal-measures, and that there is no evidence of Upper Coal-measures. Conglomerates of water-worn pebbles are also present, the pebbles being derived

plant-petrifications, possibly of earlier age than the sandstones and shales in which they occur. Two distinct and unmingled faunas are present in the rocks: one consists of fresh-water Lamellibranchs, and the other of marine fishes, Cephalopods, and Lamellibranchs; and the evidence as to horizon obtained from them agrees with that yielded by the plant-remains. The paper concludes with a bibliography.

2. "The Titaniferous Basalts of the Western Mediterranean." By Dr. Henry S. Washington, For. Corr. Geol. Soc.

In 1905 the author visited the volcanic districts of Catalonia, Sardinia, Pantelleria, and Linosa. He recognizes the existence in this region of a hitherto unrecognized petrographic province, in which the basalts contain a remarkably high percentage of titanium. The rocks are of Tertiary age. Labradorite, augite, and olivine are the essential minerals, with titaniferous magnetite and apatite, and in some cases subordinate nepheline. The rocks vary from compact to highly vesicular; they are not conspicuously porphyritic, though small phenocrysts of augite and olivine, and occasionally felspar, are sometimes present. Olivine nodules occur in some cases. The textures are those common in basalts, and ophitic relations are almost wanting. A series of analyses is given; the silica varies from 44 to 52 per cent., the alumina from 12 to 19, and the titanium-oxide from 2 to 5. The last oxide appears to be chiefly contained in titaniferous magnetite. Phosphoric pentoxide is distinctly abundant, and appears to vary, as the titanium does, with the amount of iron-oxides. Soda is dominant over potash in every instance. The augites are almost, if not quite, colourless. The classification of the rocks according to the quantitative system is discussed, and the majority of the basalts fall into the 'Salfemane' class, the exceptions being some of the Sardinian basalts and that of Graham's Island.

The extent of the region is as yet problematical, and the author points out that along the southern coast of France there are several 'basaltic' volcanoes, and it is possible that these may eventually turn out to be connecting links between the rocks of Sardinia and those of Catalonia, or possibly extrusion southward is indicated by the occurrence of phonolite at Maid Gharian, near Tripoli.

CORRESPONDENCE.

THE SOMABULA DIAMOND FIELD.

Sir,—Some months ago Sir John Willoughby presented to the Museum of Practical Geology a selection of minerals, accompanied by photographs and plans, to illustrate the geology of the Rhodesian diamond fields. These are now on exhibition on the main floor of the Museum. It fell to my lot to determine the minerals, and as the results are not exactly the same as those obtained by Mr. Mennell and given in his paper on the Somabula diamond field in the October number of the Geological Magazine, I take the liberty of sending you a few notes.

The principal discrepancy between our results is that the remarkable variety of enstatite, very hard and sometimes of a red-brown colour, which he describes as common in the deposits, is absent from all the collections which I have seen. Staurolite, on the other hand, which he does not mention, is very abundant. It occurs in worn crystals, black or dark brown, and with crystalline faces not good enough for measurement on the reflecting goniometer. The angles, however, agree well with those of staurolite. A curious fact is that no cross twins, so characteristic of this mineral, were observed among the crystals. Seeing that kyanite is so abundant, the presence of staurolite is exactly what might be expected. Mr. Mennell is not disposed to agree with Professor Gregory that the diamonds may have been derived from pegmatites, but the conclusion to which I was led by an inspection of the minerals of the alluvial deposit was that they could have come only from the margin of a granite and a contact auréole. The whole paragenesis indicates this. Not one of the minerals I have seen resembles those of the Kimberley diamond pipes. JOHN S. FLETT.

THE TRIMINGHAM CHALK.

SIR,—It seems to me also desirable to make a few comments on Mr. Brydone's letter in your November number. I did not "affect to regard" his note about his use of the magnetic for the true north "as addressed to myself personally." The communication, though it also expressed Mr. Hill's views, was written by myself to save time and trouble. Our remark was not intended as a criticism of anybody, but to explain why we had not altered the terms which we began to employ fourteen years ago, when our attention was concentrated more on the hypothesis advanced in the Geological Survey Memoir than on verbal details. We took those terms from the general direction of the coast, as shown on the Ordnance Survey Map, and I maintain that our practice, the statements in my note (except that the misprint, Weymouth for Weybourne, escaped correction), and my use of the word 'trend' are correct. The "trend of a coast" is not "ever varying from point to point and as you take it at the base or top of the cliff," but it expresses, according to Nares, Johnson, Webster, and others, the general direction, especially where there is a bending, of a coast, mountain chain, etc.

I never asserted the arch in my sketch to be identical with that to which Mr. Brydone referred in his papers. I said "the isolation of the more notable bluff is now complete," and gave a description of what then remained. My sketch and the photograph published by Mr. Hudleston in your November number exhibit the later stages of the work begun in October, 1905. My purpose in stating that a certain mass of chalk was a separate boulder was to imply, not that Mr. Brydone had denied this, but that the fact, under all the circumstances, diminished rather than increased the probability of a neighbouring mass being a seastack.

In regard to the line (*g*) in my sketch (the basement bed, according to Mr. Brydone, of the grey chalk) and my missing it on the opposite side, I can only plead the difficulty of seeing what one believes to be non-existent, but must confess that I did not understand him to mean that the *O. lunata* chalk had such a curiously irregular surface as he assigns to it in his last letter; that, however, in my opinion, only increases the difficulties in his hypothesis of an intra-Cretaceous unconformity. As this hypothesis appeared to me (as it still does) a fundamental one, and the other evidence insufficient to overcome its inherent improbability, I considered myself justified in limiting my criticism to the questions which lay within my more special field of work, and am now content to await further developments as the sea continues its inroads.

T. G. Bonney.

9, Scroope Terrace, Cambridge.

THICKNESS OF LAND-ICE.

Sir,—I have just sufficient acquaintance with your reviewer of Chamberlin & Salisbury's Text-book, vol. i. to be able to discuss what was in his mind in penning the sentence to which Professor Schwarz takes exception in your November number, though I shall not venture to defend his gratuitous interjection of a reference to Professor Schwarz's views on the occasion in question.

Professor Schwarz claims that certain physicists have proved by calculation that ice cannot attain a greater thickness on the earth's surface than 1,400 to 1,600 feet, and with implicit faith in this calculation he seeks to reconcile the result with the geological evidence. The reviewer, however, probably lacking sufficient knowledge of physics to criticize the calculation, and being also doubtful whether the result is one on which all physicists are agreed, has fallen back upon the available geographical and geological evidence, and on this evidence alone has felt no hesitation in rejecting the postulated limits. He has, no doubt, considered that the Greenland ice-sheet, as described by Peary, must at its maximum far exceed the thickness allowed by these physicists; and he probably also still believes that the Antarctic ice in the valleys of the interior surpasses this limit, in spite of the ingenious argument of Professor Schwarz as to the progressive deepening of such valleys.

Then, as regards bygone glaciation, the reviewer perhaps remembered the glacial phenomena in British Columbia, where there is every indication that ice-sheets have filled pre-existing valleys to a much greater depth than 2,000 feet; and he may have recalled the conditions in the north-eastern portion of the United States, where the uplift of boulders in the Adirondacks, if due, as usually believed, to land-ice, must imply a thickness of ice on the Canadian lowland far exceeding the supposed limit.

Or without going so far afield, he may have had in mind the

conditions of glaciation in the Isle of Man, where the highest summit, over 2,000 feet above present sea-level, has been striated transversely to the direction of the hill-range by ice which must have risen considerably above the summit, while there is strong evidence that the same ice-sheet filled up the adjacent basin, now occupied by the Irish Sea, which was certainly in existence before the glaciation. And indeed, since I know that this reviewer accepts the 'land-ice theory' for our glacial drifts he would find no dearth of instances where the geological evidence is incompatible with the restriction supported by Professor Schwarz.

Furthermore, I have reason to believe that the reviewer gathered from at least one physicist that the calculation in question would not be trustworthy under the conditions of a moving ice-sheet. In short, this reviewer and I are at one in concluding that the evidence for the past and present existence of ice of greater thickness than 1,600 feet is so strong that the physicists who wish to apply this limitation may be advised, in their own interest, to revise their calculations.

G. W. Lamplugh.

Nottingham.
November 7th, 1906.

THE KEISLEY LIMESTONE.

Sir,—While welcoming Dr. Marr's paper on the Keisley limestone, in your November issue, as a most important addition to our knowledge of that rock, I should like to point out a slight inaccuracy repeated from his and Nicholson's previous paper on the Cross Fell inlier—a mistake discovered several years ago while accompanying Professor P. F. Kendall's field class in Westmorland.

Dr. Marr says (quoting from the previous paper)—"at a point where a tributary stream (Rundale Beck) enters Swindale from the east," etc. This should be *Small Burn*, and not Rundale Beck.

His description of the *Staurocephalus* limestone applies to the beds below the junction of Small Burn and Swindale Beck, while around the junction of Rundale (or Great Rundale) Beck and Swindale Beck, about 220 yards further south, the Stockdale shales are developed, into which a lamprophyre dyke is intruded, as shown in the section on the map accompanying the paper on the Cross Fell inlier.

The streams are correctly named in the description of this area in the Survey Memoir on "The Geology of Appleby, Ullswater, and Haweswater" (pp. 36 and 41).

The names of the streams are taken from the 6-inch Ordnance Map, and I take this opportunity of pointing out the mistake, so that strangers to the district may not be misled by the wrong naming of the stream, if they should ever wish to make a closer acquaintance with this interesting bed in the field.

E. J. Edwards.

12, Norwood Terrace, Leeds.
November 8th, 1906.

THE LOOSE VALLEY, ETC., NEAR MAIDSTONE.

Valleys of subsidence initiated by Swallow-holes.

SIR,—My attention has for some time been called to the formation of valleys from what seems to me a new point of view, and both at and near Malling the evidence for this seems as clear as one can expect in these cases.

This evidence seems to point that these valleys, all of which are in the same formation, viz. the Hythe Beds, and I would also include some valleys in the Chalk, have been initiated by swallow-holes, and that these have been in their primary stage *formed from below*, by the uprise of the water up lines of weakness under hydrostatic pressure.

Many of these swallow-holes still exist parallel with the course of the valley, but high and dry, and many of these are known by local names as Jacob's Hole, Baldwin's Hole, etc. Some still contain water, and are situated *at the heads* of some of the side valleys and are fed by springs.

It appears also that much more has been done by way of erosion by the invisible underground stream than by the visible one, and the shape of the valley sides, very steep in places, indicates subsidence consequent on the giving way of the valley under the weight above, rather than by subaerial action alone, though this of course has contributed.

In the case of Loose Valley we have instances of the loss of the stream for over a quarter and half a mile respectively, not an unusual occurrence in limestone areas, but here accompanied by what, as far as I know, is a most unusual feature, viz., that the loss of the valley accompanies the loss of the stream, and that where this occurs the valley ceases practically to exist, and is bridged over. Another governing factor seems to be the varying proportion of the Rag to the soft Hassock, as where the valley ceases there the Hassock is very thin and there the quarries occur, naturally at the place where the Rag is thicker.

Another interesting feature is the fact that there are various water-levels in this valley, and one case is that of a spring pond at a much higher level than the river and running over into it, a phase in the former state of that valley when this pond was a deep swallow-hole. Again, too, there occur many natural pools along the course of the river, and where these occur the valley assumes a crater-shaped form as if these pools also had once been deep swallow-holes, now worn away. That the loss of the river and of the valley must have escaped notice when the geological map was made, is shown by the fact that at the part where the last issue of the river takes place at the foot of the rise which there terminates the valley, a fault has been mapped, cutting off the Atherfield Clay, which it appears merely passes under that rise.

But I think I have said enough to show that both the Loose and the Malling Valleys deserve attention from all those interested in valley formation.

F. J. BENNETT.

WEST MALLING.
October 3rd, 1906.

THE ZONES OF THE LOWER CHALK.

SIR,—In the November number, p. 507, Mr. Jukes-Browne comments on my "curious method of estimating the affinities of a fauna."[1] The faunas compared are those of—

A. The Chalk above the Burwell Rock of Cambridgeshire and Suffolk, containing 51 species, 33 of these being common to the Burwell Rock.

B. The Burwell Rock of Cambridgeshire, with 87 species.

C. The Chalk Marl of Cambridgeshire, with 25 species, of which 23 occur in the Burwell Rock.

The "more rational" course advocated by Mr. Jukes-Browne is to ascertain whether A or C contains the greater number of species common to B, irrespective of the fact that fauna A is twice as large as fauna C.

By his method, since all three faunas are closely related, the larger of the two faunas A and C is bound to appear the more closely related to B. Therefore I prefer to compare the percentage of forms in A common to B (67 per cent.) with the percentage of forms in C common to B (92 per cent.).

With Mr. Jukes-Browne's statement that taking a larger area, including Bedford and Hertford, the fauna of the Totternhoe Stone, excluding reptiles, "comprises 96 species, of which only 23 range downward into the Chalk Marl of the counties mentioned," I cannot agree. His own General Memoir records 31 such forms; and I have already recorded *Nautilus elegans* in addition to all these. The Chalk Marl of these counties contains 35 species, of which 32 are common to the 'Totternhoe Stone,' i.e. 91 per cent., a figure in close agreement with the percentage quoted for the smaller area. In support of my contention that the zone of *Ammonites varians* should include the Totternhoe Stone, I give the subjoined chart, p. 575. Upon this I have plotted most of the species in the Burwell Rock of Cambridgeshire which are not recorded from the Chalk Marl of that county. The species chosen occur in the Lower Chalk of Folkestone and also at some intermediate locality.

Forms above the line **A B C** have not been recorded below the 'Totternhoe Stone' of the region indicated.

Forms below the line **A B C** are not recorded above the Chalk Marl (unless marked *).

Forms actually upon the line **A B C** occur in the 'Totternhoe Stone' and also in the Chalk Marl.

Thus the line **A B C** represents the base of the 'Totternhoe Stone.'

The straight line **A D** represents the top of the 'Totternhoe Stone,' and also, as I maintain, the top of the zone of *Ammonites varians*.

Thus we see that the fauna which occurs above the base of the 'Totternhoe Stone' in the north, is within the Chalk Marl of the south, and that the transition is gradual.

But, on the other hand, the line **A D** separates two different faunas.

[1] See my Article "Zones of the Lower Chalk," GEOL. MAG., Sept. 1906, p. 412.

Below it there is always the *Ammonites varians* fauna, containing: *Pecten elongatus, Discoidea subuculus, Nautilus deslongchampsianus, Nautilus elegans, Turrilites, Baculites,* and *Actinocamax lanceolatus.*

Above it is the *Holaster* Chalk with *Cidaris Bowerbanki, Echinocyphus difficilis, Holaster trecensis, Discoidea cylindrica* (hemispherical form), *Ptychodus decurrens.*

Cambridgeshire.	Bedfordshire and Hertfordshire.	Oxfordshire, Buckinghamshire, and Berkshire.	Folkestone.
Chalk containing *Cidaris Bowerbanki, Ptychodus decurrens, Holaster trecensis, Echinocyphus difficilis,* and *Discoidea cylindrica* (hemispherical form).			
D			A
Oxyrhina Mantelli.	*O. Mantelli.*	...	*O. Mantelli.*
Protosphyræna ferox.[1]	*P. ferox.*	...	*P. ferox.*
Notidanus microdon.	...	...	*N. microdon.*
Corax falcatus.	...	...	*C. falcatus.*
Ammonites cenomanensis.	*A. cenomanensis.*	...	*A. cenomanensis.*
Actinocamax lanceolatus.	*Act. lanceolatus.*	...	*Act. lanceolatus.*
Pecten Beaveri.	*P. Beaveri.*	*P. Beaveri.*	**P. Beaveri.*
Pecten elongatus.	*P. elongatus.*	*P. elongatus.*	*P. elongatus.*
Pholadomya decussata.	*Ph. decussata.*	*Ph. decussata.*	*Ph. decussata.*
Inoceramus striatus.	...	*I. striatus.*	*I. striatus.*
Ammonites navicularis.	*A. navicularis.*	*A. navicularis.*	*A. navicularis.*
Hemiaster Morrisi.	*H. Morrisi.*	*H. Morrisi.*	**H. Morrisi.*
Solarium.	...	*Solarium.*	*Solarium.*
Nautilus deslongchampsianus.	... B	*N. deslongchampsianus.*	*N. deslongchampsianus*
Turrilites costatus.	...	*T. costatus.*	*T. costatus.*
Turrilites Scheuchzerianus.	*T. Scheuchzerianus.*	*T. Scheuchzerianus.*	*T. Scheuchzerianus.*
Ammonites rhotomagensis.	*A. rhotomagensis.*	**A. rhotomagensis.*	**A. rhotomagensis.*
Pleurotomaria.	*Pleurotomaria.*	**Pleurotomaria.*	*Pleurotomaria.*
Neithea quinquecostata.	*N. quinquecostata.*	**N. quinquecostata.*	*N. quinquecostata.*
Lima aspera.	*L. aspera.*	**L. aspera.*	*L. aspera.*
Ammonites Coupei.	*A. Coupei.*	*A. Coupei.*	*A. Coupei.*
Palæga Carteri.	*P. Carteri.*	*P. Carteri.*	*P. Carteri.*
Aporrhais.	*Aporrhais.*	*Aporrhais.*	*Aporrhais.*
Scaphites æqualis.	*S. æqualis.*	*S. æqualis.*	*S. æqualis.*
Ammonites varians.	*A. varians.*	**A. varians.*	*A. varians.*
Nautilus elegans.	**N. elegans.*	*N. elegans.*	*N. elegans.*
Discoidea subuculus.	...	*D. subuculus.*	*D. subuculus.*
Rhynchonella Martini.	*R. Martini.*	*R. Martini.*	*R. Martini.*
Ammonites Mantelli.	*A. Mantelli.*	*A. Mantelli.*	*A. Mantelli.*
Rhynchonella grasiana.	**R. grasiana.*	**R. grasiana.*	**R. grasiana.*
Turrilites tuberculatus.	...	*T. tuberculatus.*	*T. tuberculatus.*
Lima globosa.	**L. globosa.*	**L. globosa.*	*L. globosa.*
Inoceramus latus.	**I. latus.*	*I. latus.*	...
And 14 others.	Etc.	Etc.	Etc.
C			

Fossils of the Totternhoe Stone.

Fossils of the Chalk Marl.

In conclusion, I may say that the Discoideas from the *Holaster trecensis* beds of Cambridgeshire seem to be distinguishable from those in the zone of *A. varians* (including the Burwell Rock), but I am not yet sure of being able to separate them from the large forms in that zone in the south.

[1] Not listed in the General Memoir, but fairly common at Burwell.

On the other hand, *Cidaris Bowerbanki* is a characteristic and easily recognisable fossil in the Chalk above the zone of *A. varians* as understood by me. It has only been recorded in the lower zone near Lewes, and does not occur in the 'Totternhoe Stone.' As an index, it seems much more suitable and definite than any of those species suggested by Mr. Jukes-Browne.

I still maintain, however, that it is more practicable to use the "Two Holasters," which are commoner fossils; and it does not seem unreasonable to use in partnership two contemporary species of different habitat to indicate beds deposited under variable conditions at the same time. Mr. Jukes-Browne has shown at some length that my brief summary of the occurrences of *Holaster subglobosus* contains some inaccuracies. This I am willing to admit; but the necessary corrections do not affect the main conclusion—that it requires the *two* Holasters to define the whole zone.

T. O. Bosworth.

St. John's College,
Cambridge.

OBITUARY

FREDERICK JUSTEN, F.L.S.

Born February 29, 1832. Died November 20, 1906.

It is with deep regret that we record the death, on Tuesday, 20th November, of our dear and valued friend, Mr. Frederick Justen, F.L.S., the publisher of this journal.

Mr. Justen was born at Bonn on the 29th February, 1832, and came to England as a German Assistant to the firm of Messrs. Dulau & Co., 37, Soho Square, W., in 1851.

Upon the decease of the late Mr. Twentyman, the then acting partner, Mr. Justen became the sole proprietor of the firm, and for many years devoted his energies to supplying the requirements of the British Museum and the Libraries of the various scientific societies of London and the provinces with foreign publications.

It was his strong sympathy with the aims and objects of the Geological and Palæontographical Societies, the Geologists' Association, and other kindred institutions, that prompted him, in 1895—irrespective of any pecuniary considerations whatever—to undertake the publication of the Geological Magazine, in the success of which he always took the deepest interest.

It is not too much to affirm that the onward progress of the Geological Magazine in the last 12 years has been mainly due to the public-spirited support given to it by Mr. Frederick Justen, and no one of all our friends and supporters rejoiced more than he did, when, in February last, the 500th monthly number of this journal was issued from 37, Soho Square.

Notwithstanding the great personal loss which the death of Mr. Justen has caused to us, we are happy to state that the business relations with the firm of Messrs. Dulau and Company will be continued in the same cordial manner as heretofore. H. W.

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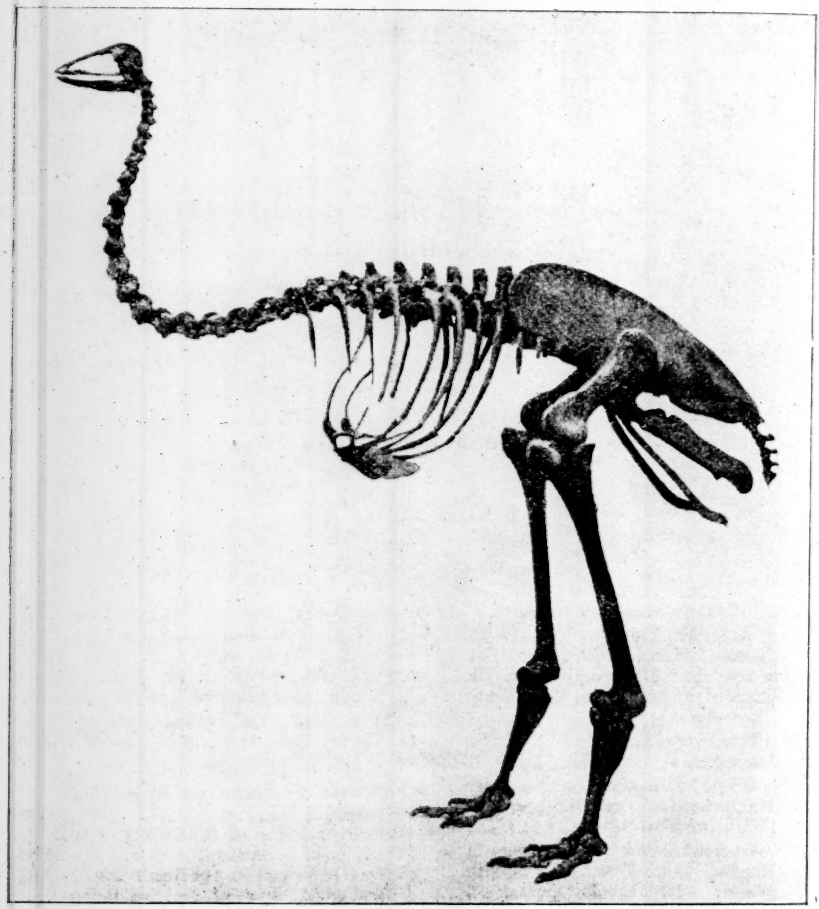

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